BULLETIN

OF

THE INSTITUTE OF PHYSICS

AND

THE PHYSICAL SOCIETY

VOLUME 12 . NUMBER 2 . FEBRUARY, 1961

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BULLETIN
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Vol. 12, No. 2 FEBRUARY, 1961

The admission of physics students to universities

N. THOMPSON
B.Sc., Ph.D., F.Inst.P.
University of Bristol

[The Chairman's address to the Education Group, given on October 19, 1960]

In 1953 the number of applications for admission to the Honours School of Physics at Bristol was 276, of whom we were able to admit 48. By 1960, the number of applications had risen to 1,007, of whom we admitted 68. The discrepancy between the two numbers in 1953 was sufficiently disquieting; but if the figures for 1960 represent the real level of competition among physics students for university entrance the situation would be alarming. My purpose is to show that, in fact, the problem is not so serious as these figures would suggest, and that it is not even the same problem as it might appear to be at a first glance.

There are two questions that can be asked: firstly, to what extent are the above figures representative of the country as a whole and, secondly, to what extent do they present a true picture. Some answer to the first can be obtained from data kindly supplied to me by Heads of Departments up and down the country early in 1960, and relating to 1959 applications. Figures are available for four London colleges, eight English provincial universities and one Welsh college. (They are not obtainable for Oxford, Cambridge and Durham, since admission there is to a college rather than to a department; Reading and Keele do not admit in the first instance to an Honours course, and the system in Scottish universities is so different that an attempt at comparison is not worth while). The ratio of applications to admissions in the 13 institutions ranges from 2·4 to 12·8, most of the results lying in the range 6 to 11, and giving a weighted mean of 8·5. Bristol, with 12·0 in 1959, was therefore among the more popular universities.

A number of physics departments were also able to furnish information about applications and admissions in the past. This information, particularly as relating to numbers of applications, is rather less complete in the earlier years, but it is possible to form an estimate of the trend from 1953-59. The results are shown in the first two lines of Table 1, normalized to 100 in 1953. The third line gives the ratio of the applications to admissions, normalized to 8·5 in 1959.

TABLE 1.

	1953	*1954*	*1955*	*1956*	*1957*	*1958*	*1959*
Admissions	100	110	127	134	151	165	168
Applications	100	111	128	157	206	249	285
Ratio	5·0	5·1	5·1	5·9	6·8	7·6	8·5

The rapid increase in the number of applications will surprise nobody: the considerable increase in the number of admissions may be less generally known. The increase in the ratio is also in accordance with general belief and —bearing in mind the limitations of both sets of figures— supports our experience at Bristol, although the changes are less pronounced. We may thus conclude that Bristol is not exceptional in its high ratio of applications to places, but may be a rather extreme case.

Turning now to the second question of the extent to which the picture thus presented is a true one, we can again start with our own position. In 1953, all those of the 276 applicants who did not come to Bristol were circularized to find out what, in fact, had become of them. The answers were analyzed into four categories:—

(*a*) Already in attendance at a university or university college, or having a firm offer of a place for the following year, or—a few only—taking degree courses at technical colleges of good standing.

(*b*) Still at school.

(*c*) In paid employment.

(*d*) Otherwise engaged. (e.g. doing National Service, etc.)

The same exercise was carried out on the non-accepted candidates in 1956, and again in 1959 using the same categories. On all three occasions the replies were sufficiently numerous to make the results significant (94½%, 98% and 93½% of all applicants, respectively). The numbers in the four groups mentioned, expressed

as a percentage of those students about whom anything is known is shown in Table 2.

TABLE 2.

	1953	*1956*	*1959*	
A+	73	72½	73	
B	11	13	12	
C	8	8	12	} *
D	8	6½	3	} *

* No National Service !

In this table Group A has been augmented by those students accepted at Bristol. Two striking facts emerge:—Firstly the high proportion of the original group of applicants who are already at a university (~73%): and secondly, the constancy of this proportion over the six years, in spite of the fact that, during the same period the number of applications had increased from 276 to 861. We may further remark that almost all of those students still at school (group B) and some of those doing National Service (group D in 1953 and 1956) were intending to apply again for admission in the following year. Presumably something of the order of 73% of them would be admitted on this second application, so that the fraction of the original applicants who would reach a university sometime rises to over 80%.

It thus appears that, statistically, the chance of a student who applies to Bristol getting to a university somewhere was about 3/4—a figure which bears no relation to the ratio of places to applicants—about 1/6, 1/8 and 1/12 for the three years in question. The explanation is, of course that every candidate submits more than one application, and to obtain any realistic picture, the ratio of applicants to places must be divided by this " multiplicity factor ". It is unfortunately not possible to obtain an exact value for the multiplicity factor, nor any certain idea of the way in which it is changing with time, but some information is available. One estimate was obtained by enquiring of the 1959 first-year class in Physics at Bristol how many applications *they* had submitted in the previous year. Oxford and Cambridge, if included, were to count one, but the London colleges were to be counted separately. The result, based on 63 replies, was a mean of 3·8. There are reasons for believing that the average for the country as a whole may be higher than this. Confirmation of the suspicion is provided by an enquiry made by Professor Conn at Exeter which gave a result of 4·25 for 1959—and rather less in the two preceding years. The impression of some other Professors—and of the Bristol students themselves—is that the national average would be above 3·8: certainly 4·0 would not seem to be too high.

If this result is combined with that quoted above for the national ratio of applications to places, 8·5 in 1959, the resulting ratio of *applicants* to places becomes 8·5/4·0=2·1. Since data for Oxford and Cambridge cannot be included in such a calculation, and since the numbers thus excluded are large, no great accuracy can be claimed for the result: but it cannot be very far wrong. Inverting the result, it means that, nationally, about 1/2 of the 1959 applicants were admitted somewhere—and not 3/4 as was concluded from the Bristol sample. If the multiplicity factor were higher than the estimated 4·0, the discrepancy would be reduced, but this is unlikely to be the whole explanation. One possible factor is that, if Bristol is known to be a popular university, weaker candidates may not apply, and thus those who do apply have, statistically, a higher probability of being admitted somewhere. (A similar enquiry among applicants to Cambridge for example might well show that almost all of them are admitted *somewhere*).

A second source of information about the multiplicity factor is the Report on Applications for Admission to Universities. This investigation, made at the instigation of the Committee of Vice-Chancellors and Principals refers to applications made in 1955. The conclusion there reached is that the multiplicity factor relating to applicants for degrees in Science is 2·5. This is a lower limit, since unsuccessful applications to Oxford and Cambridge were not included in the total. Applying a correction for this fact clearly cannot possibly make the figure reach 3·5. If one-fifth of the students concerned had applied without success to either Oxford or Cambridge the corrected figure would have been 2·7: this we shall take as the best available estimate.

Taking the ratio of applications to places for 1955 from Table 1 as 5·1 we find as above, that the ratio of applicants to places is 5·1/2·7=1·9. (Compare 2·1 for 1959). This is the least precise of all the numerical results quoted so far, but it does suggest that the real situation has not changed radically between 1955 and 1959, and that a large part of the increase shown by the third row of Table 1 is really an increase in the multiplicity factor. Thus again the more limited but more precise results obtained from the Bristol sample are confirmed.

Finally, it is of interest to look further at those students who were not admitted, and who are no longer at school. These are groups (*c*) and (*d*) and, in the 1959 investigation, numbered together 123. Twenty-three of them describe themselves as " student apprentices " or some such term, and state that they are candidates for Dip. Tech. (A further 17 also describe themselves by some similar name without giving any details of courses of study, if any). At least some of these have preferred their present course to the possibility of reading for a university degree, mainly for financial reasons.

To obtain some idea of the academic standards of this group, the pass lists of the various examining boards were consulted for information about all except the 23 Dip.Tech. students. No trace could be found of 28 of them—meaning either that they did not take the examination which they intended to take when applying for admission, or that they did not take any examination at all. Of the remaining 72, 22 did not reach the minimum standard required for matriculation—two " A " level passes at 40%. The number that would have qualified for admission to a university depends on the standard required above this minimum. A requirement of two " A " level passes at 60% would have produced eight students. A requirement of three passes at 40% would have produced 16 more, while the minimum of two passes at 40% would have produced another 26. Of the first eight, two had withdrawn their

applications before a decision on them had been reached, and three more had been offered places at Bristol which they had declined for one reason or another. Thus there remain only three of the original 861 who might justifiably feel aggreived at being deprived of a university place.

It may be asserted—as indeed has already been admitted—that the Bristol applicants do not represent a true random sample. We can therefore usefully consider the results of running the " clearing-up house " for physics students. As will probably be known, this organization comes into operation in early September and serves to put students still looking for university places into contact with universities still looking for students. In 1959, it was run on a small scale, on the initiative of Dr. Elton, but in 1960 its activities were increased, and the results for the latter year are possibly more significant. Sixty-two students sought help from the organization. The number of these qualified with two passes at 60% was eight: with three passes at 40%, a further 40; and with two passes at 40% a further nine. The number of places known to be vacant at universities was about 45, with about the same number of vacancies at technical colleges for students to read for a degree, and the same again to read for Dip.Tech. Knowing also the entrance requirements of the universities and colleges concerned, the clearing-up house was able to put all the students in touch with an institution whose requirements matched their attainments. Many of them preferred, for a variety of reasons, not to take advantage of the opportunity thus offered, but of the 62 students 21 are known to be at universities, ten at technical colleges (six and four respectively as a result of the operation of the clearing-up house), while at least 16 have returned to school. It may be that there were other students whose cases did not come to the attention of the clearing-up house, but since all universities were asked to send in particulars of any good student whom they were unable to accept for lack of space, these numbers are likely to be small. Looking at the detailed lists of students and vacancies with this in mind, it is clear that the number of good students who could not have gained entrance to some university (although possibly not to one of their first choice) must have been very small indeed.

This being the case, we should look again at the large disparity between applications and places (eight to one), which formed our starting point. It is clear that an immediate and urgent problem exists which is mainly one of administration. The present procedure for admitting students to universities is wasteful of time and effort for students, universities and headmasters alike. In those departments dealing with the larger numbers it is becoming increasingly difficult to do justice to all the applications and smaller departments will find themselves in the same plight in a few years, if the expected increase in numbers comes about. Some kind of central organization is clearly becoming essential if the whole machinery is not to break down. It is not impossible to devise such an organization which will maintain the essential freedom of the student to choose his university and of the university to select its students. Unless the universities can agree voluntarily and quickly on the form that such an organization should take the situation may pass beyond their control.

The second conclusion to be drawn from the statistics relates to a less clear-cut and more controversial matter. At present almost all universities require a standard in " A " level higher than bare matriculation before they will admit a student to an honours degree course. If these requirements were withdrawn, an additional group of students, drawn from those already applying, would become qualified for admission. From the above data it is possible to make an estimate of what the increase would be. Expressed as a fraction of the present annual intake it is unlikely to lie outside of the range 1/4 to 1/2, and 1/3 will do as a rough guide. This figure, it should be emphasized, involves a good deal of guess-work and takes no account of population changes or other sociological factors.

It is the existence of this reservoir of second-rate talent that raises so many questions. Is it really second-rate ? Does any moral obligation rest on the universities to try to absorb it ? Is it big enough to provide for the proposed university expansion—or more than enough ? If the universities are intending to maintain the present standards of entrance qualification, should they say so unequivocally ? If the standards are reduced, would it be possible to reach a level worthy of being called an honours degree without the introduction of a four-year degree course ? Is it desirable, for all concerned, that students of widely diverse capabilities should all pursue the same course of study, or even all attend the same institution ? These, and many other inter-related problems are likely to be hotly debated in educational circles in the near future: but the debate cannot be excessively prolonged—the problems are urgent.

Bulletin of The Institute of Physics and The Physical Society

Developments in technical and technological education with special regard to physics

By J. TOPPING

M.Sc., Ph.D., F.Inst.P.

Brunel College of Technology, London

[A paper prepared for the International Conference on Physics Education held in Paris, July-August, 1960.]

Technical Colleges in Britain grew up to provide some measure of training for those who had left school early and were employed in industry. Originally all the instruction was in evening classes, but later enlightened firms arranged for their apprentices to attend classes during the day and there grew up a system of "part-time release" whereby apprentices are now allowed to attend classes on one day a week, usually supplemented by evening classes. In due course, some of the Colleges attracted full-time students and a feature of the period since the war has been the increase in the number of students attending full-time and sandwich courses. In 1938, the total number of full-time students in all Technical Colleges (excluding Art Establishments) was only 20,000, whereas in 1957 there were about 77,000, as well as about 450,000 in part-time day classes and nearly 900,000 in evening classes. To-day there are about 550 colleges, varying greatly in size and in the level of the work they undertake. Nearly all are maintained by Local Education Authorities and are financed partly by the Ministry of Education. Many of the students are adults ; the youngest are 15-16 years of age.

At the lowest level there are courses suitable for the training of craftsmen; at the next stage there are courses for technicians leading to the Ordinary National Certificate and the Higher National Certificate, and above this there are courses leading to a university degree or the Diploma in Technology or other qualification appropriate for entrance into membership of a Professional Institution, such as The Institute of Physics. In the past it has been possible for one college to provide a very wide range of courses, but recently there has been more specialization, for in 1956, the whole structure of technical education was re-ordered, and there are now Local, Area and Regional Colleges, each having definite and more restricted functions. There are also a few Colleges of Advanced Technology which concentrate entirely on advanced studies including postgraduate and research work.

TRAINING OF TECHNICIANS

Industry needs large numbers of well-trained technicians, who by technical education and practical training are qualified to do a multitude of jobs; to assemble and use scientific apparatus, sometimes to construct it and often (and invaluably) to suggest modifications in design and arrangement. Their skills and abilities range widely; they are always more than skilled craftsmen, sometimes they are not easily distinguishable from technologists. Teams of technologists and technicians are a feature of our industrial and laboratory arrangements.

Many young men qualify as technicians through attending National Certificate courses at technical colleges. National Certificate courses in engineering were started about 1923 but courses in applied physics were introduced as late as 1945 and are now established in certain approved technical colleges in various parts of the country. The total number of students in applied physics courses is shown in Table I below.

TABLE I

	Number of Colleges		*Number of Candidates*		*Number of Passes*	
Year	*Higher*	*Ordinary*	*Higher*	*Ordinary*	*Higher*	*Ordinary*
1947	—	1	—	2	—	2
1951	5	12	29	111	25	59
1955	11	27	82	309	54	204
1960	29	46	355	914	246	584

There are National Certificate courses in fourteen subjects other than applied physics; the bulk of the students are in engineering courses. In 1957 there were 31,835 candidates for the Ordinary National Certificate of whom 16,176 passed, compared with 5,797 entrants and 3,313 passes in 1938.

The courses leading to the Ordinary National Certificate in Applied Physics are part-time courses of study extending over at least three years and include mathematics, chemistry, workshop practice and drawing as

well as physics and applied physics. The courses leading to the Higher Certificate are also part-time; they extend over a further two years and include mathematics, physics and applied physics.

Entrants to the first year of the Ordinary course should have had full-time continuous education up to the age of sixteen or if they had left school earlier, should have completed satisfactorily a junior part-time course of two years' duration. In fact, quite a number of students come from grammar schools and some are granted exemption from parts of the course on their achievement in the General Certificate of Education examinations.

During the Ordinary course, students are required to pass examinations in physics, mathematics, chemistry, workshop practice and drawing, and at the end of the third year to pass assessed examinations in mathematics, physics and applied physics. To qualify for the award of an Ordinary National Certificate, a candidate must also satisfy certain conditions concerning attendance, homework and laboratory work. Similar conditions hold for the higher courses and assessed examinations for the Higher National Certificate are in mathematics, physics and applied physics.

In the Ordinary course, classes in workshop practice and drawing occupy an important place. They are designed to acquaint the student with the use of ordinary workshop tools and with the techniques employed in working wood, metal and glass, and also to enable him to prepare and understand the working drawings necessary in this and similar work. The acquaintance with the methods and possibilities is perhaps more important than the acquisition of skills. The other ancillary subject is chemistry for which the syllabus is wide rather than deep but the contents of the course are selected with the special needs of the physicist in mind. The main subjects of the course are mathematics and physics, including applied physics. They are main subjects for vocational reasons, but handled properly they can be of great value educationally. Our aim in the teaching of these subjects is two-fold. Firstly, it is to help the students to acquire a knowledge of physics and of some of the applications of physics in industry, and secondly, in so doing, to help them to appreciate the scientific approach to the problem, how a physicist tackles the new and unknown, and how he expresses a scientific answer to a question.

The physics syllabus has selections from all the main branches of the subject, whilst the applied physics is chiefly concerned with physical measurements in industry. Physics and applied physics are often taught separately and by different teachers; specialists from industry sometimes teach the applied physics, but it is recognized that much can be gained from teaching the content of our syllabuses in physics and applied physics as one subject, call it what you will. Not only is a division somewhat artificial and rather arbitrary, but it may have a deleterious effect on the teaching of physics which to National Certificate students particularly should be constantly fertilized by using practical examples. The syllabuses of the advanced courses in applied physics at the various colleges are moulded by the nature of local industry, but they often include a fair amount of electronics and high vacuum technology, and one or more of such subjects as fluid flow, acoustics, industrial spectroscopy and X-ray technology. In these National Certificate courses one would like to see physics taught as a whole using not necessarily the traditional sequence but with an unorthodox approach through practical applications. Further, one would welcome an emphasis on the expression in clear language of the basic physical ideas and secondarily of their mathematical formulation, whilst much could be done, linked with the mathematics courses, on errors of measurement. Gaps in factual knowledge there will inevitably be, but these will be more easily filled later if the basic principles are understood, Many of those who are successful in the Ordinary National Certificate examination pass to a Higher National Certificate course. Some who succeed in gaining a Higher National Certificate proceed no further and remain technicians, but others continue their part-time studies for a further period and qualify as technologists. It is an arduous course and it is not surprising that only a small fraction of those who enter an Ordinary National Certificate course finally qualify for graduate or corporate membership of a professional institution.

EDUCATION OF TECHNOLOGISTS

Many of the technologists in industry to-day have, of course, been educated at our universities but as suggested above there are others who have come up "the hard way," that is, to have attended part-time courses in Technical Colleges and thereby achieved professional qualifications. Technical Colleges have, in main, provided two kinds of courses for technologists; those leading to a Higher National Certificate and those leading to a degree. A Higher National Certificate holder is enabled after further part-time study and experience to attain graduate membership of a professional institution. The Institute of Physics has done much to foster National Certificate courses in Applied Physics, and by means of these and its graduateship examination has provided an avenue into the profession additional to that through the universities. The number of those who have passed the graduateship examination since it was started in 1952 is small but increasing numbers of students have attended Higher National Certificate courses in applied physics as Table I shows.

Technical Colleges have also organized part-time and full-time courses leading to an external degree of the University of London. The numbers graduating in physics have never been very large;* after 1945 they increased because many of the ex-servicemen could not be accommodated in the universities, but since about 1952 they have declined. For some years, a few Technical Colleges have been feeling their way toward new schemes and new methods. Outside the Colleges too, there has, since the war, been much discussion and

* As an example of the measure of the contribution of some Technical Colleges in this field, it might be noted that in 1955/56 the total number of graduations in Britain in science and technology was 7,350, of which 1,250 were from Technical Colleges.

many reports. After what seemed an interminable period of inaction and frustration, the White Paper on Technical Education, published in February, 1956, opened the way for a real move forward. It was not merely that the Government announced its intention to spend more money on buildings, £70 million over five years, which recently has been further increased, but the White Paper did more. It made us think again of the joint contribution of the universities and the technical colleges to the education of technologists and it heralded certain changes calculated to help technical colleges to make their own special contribution.

Firstly, there was the setting up of the National Council for Technological Awards, and secondly, the creation of Colleges of Advanced Technology. Some nine colleges have already been designated Colleges of Advanced Technology. As indicated earlier they are to concentrate entirely on advanced studies and to provide a broad range of work of the highest quality. They are to undertake postgraduate work and research, and the staff are to have conditions approximating to those in universities. Accommodation for students and staff is to be much improved. All this, of course, has not yet been achieved, but much is being done and there are grounds for hope that during the next five years standards will be effectively raised.

THE NATIONAL COUNCIL FOR TECHNOLOGICAL AWARDS

Perhaps the most vital decision was the setting up of the N.C.T.A. This Council is an independent self-governing body responsible for creating and administering technological awards of high standing "available to students in technical colleges who successfully complete courses approved by the Council." The first award instituted by the Council is known as the Diploma in Technology, the course for which are designed to be equivalent in standard to honours degree courses in universities. The Council has been criticized for seemingly tying the new schemes to the university degree system from the very beginning, but this was far from the intention of the Council. The phraseology used was merely to indicate the standard of the new awards. Colleges are encouraged to grasp the opportunity of developing new courses, reflecting the technological bias of technical colleges, closely linked with industry, revealing an awareness of the modern developments in science and technology, and designed to educate as well as train some of the technologists the country needs. This is no easy task. It demands the best from educationalists and industrialists alike.

SANDWICH COURSES

Many of the courses leading to the Diploma in Technology are sandwich courses, that is, the students spend six months in college, followed by six months in industry each year, and the whole course extends over four years. It is expected that the academic and industrial periods will be as closely integrated as possible, although this is not easy to achieve. Sandwich courses have an obvious superiority over the part-time day release and evening class schemes. It is clear too that the alternation of academic study and practical experience in industry, provided these are carefully planned, is an arrangement which for some students is likely to be most fruitful and conducive to the fuller development of their powers. This is not all. Students in these courses have the opportunity, unfortunately denied to part-time students, of participating in a fuller college life and of gaining an increased measure of the benefits of a rounded education such as we expect our institutes of higher learning to offer.

For the staff of the colleges, there have been many difficult and interesting educational problems. In designing the courses they have had to consider their technological and scientific content, the place and function of liberal studies, the value of project work and the correlation of the academic work in the college and the industrial training of the students in the firms. It is necessary to enquire what type of training is appropriate to students of this kind, and how it should be related to their academic studies. Staff of Colleges have been glad to join with Education and Training Officers in firms in trying to solve some of the problems implicit in these training programmes. All this has been helped by the appointment of full-time members of staff as tutors, each responsible for a few students. Tutors visit the students in their firms and the students go back to the colleges periodically to meet their tutors to discuss with them the various jobs they have been doing and other academic, industrial or even personal matters. This may well prove the most important element in the sandwich course schemes.

DIPLOMA IN TECHNOLOGY

The number of colleges recognized so far for Diplomas in Technology courses is only 23, and there are some 95 separate courses. Many of these courses are in engineering, but they include courses in physics, mathematics, chemistry and biology. The number of students in Diploma in Technology courses at the present time is about 3,800 and of these about one quarter are attending courses in applied science. Almost half of the students are in their first year which indicates the growth in the numbers entering the courses. The number of students taking courses in Applied Physics is about 375; only 14 have so far been awarded the Diploma in Technology in Applied Physics.

In thinking of numbers of students entering Diploma in Technology courses, it should be remembered that there are two ways in. One way is for the boy or girl who leaves a grammar or public school at about 18 years of age with roughly university entrance requirements, having passed the General Certificate of Education examination in the appropriate subjects, of which two at least are at advanced level and three at ordinary level. The other way, is for the boy or girl who left school earlier usually at 16, went into industry as an apprentice, attended part-time classes at technical college for two or three years and showed the measure of his ability by passing an O.N.C. examination well. Perhaps the top 10% of the O.N.C. candidates are of the right calibre and personality to profit from courses of this kind, and are able to hold their own with the grammar school boy who stayed on longer at school. It should be said that the quality of the Diploma in Technology students is good and we have every hope that when, in a few years' time they join the ranks of technologists in good numbers, they will amply justify all that is being done for them to-day, both in the colleges and in the firms.

Recognizing that the university degree course and the Diploma in Technology course are two different ways of educating technologists to roughly the same level, it might be worthwhile to try and set down some of the ways in which the courses are different.

One important difference is the sandwich nature of the Diploma in Technology course, although there are a very few full-time courses in which students spend two years in the college and one in industry and finally another year in college.

Besides this difference in the structure of the courses there are differences in the contents of the courses and in the teaching methods employed. The differences vary from course to course, and, as an example, one might take a Diploma in Technology course in applied physics, and compare it with an honours physics course at a university. One must speak fairly generally, for just as degree courses vary from university to university so the Diploma in Technology courses reflect the outlook of the college and of the particular Department.

I will however try to outline the general form of one Diploma in Technology course with which I am familiar. In the first two years of that course there is a good, broad foundation of physics and mathematics. The third year includes further physics and mathematics, together with a choice of applied physics subjects including electronics, high vacuum technology, X-ray diffraction, applied acoustics and the physics of nuclear engineering. In the final year the study of two of these applied physics subjects is carried further, there is more physics and some additional mathematics, and each student undertakes a project which entails him in an original investigation and the important activity associated with such work—a measure of those experiences which can make the research years the most valuable part of university life.

The mathematics is carefully chosen to support the physics courses, and to include some statistics and some numerical analysis in order to give students an insight into the manner of solution of some of the real problems which physicists meet and which are often far removed from those of the mathematics lecture-room where they usually lend themselves neatly and conveniently to a precise solution.

Students also get some introduction to glass-blowing and to the machine tools of a physics or engineering workshop; they gain a familiarity with engineering drawing without becoming expert draughtsmen, and they take (and often enjoy) a short course in electrical technology, and become knowledgable about electric motors, three-phase supplies and the like, without becoming electrical engineers.

The laboratory courses in physics have been replanned, but much more thought needs to be given to this. In addition liberal studies are an important feature of the course.

Much that I have said applies not merely to Diploma in Technology courses in physics but to other courses as well. Quite generally it can be said that each Diploma in Technology course is broad-based; not only is the study of the particular technology deep enough to provide a discipline of the quality usually associated with university degree courses, but the course includes the sciences allied to the particular technology, an introduction to industrial organization, and some liberal studies. In addition, each student undertakes a project in his final year which generally is closely linked with his experience in the firm and provides him, it is hoped, with the discipline and excitement of working on a problem which for him has a research element in it. It is intended that the teaching should make use as much as possible of the student's growing industrial experience.

There are other significant ways in which the Diploma in Technology courses differ from those courses leading to an external degree of the University of London which as I have said earlier have been a feature of the programmes of some Technical Colleges in the past.

Perhaps the most important difference is the freedom the College has to design these new courses, to frame the syllabuses and to set the examinations; there are of course external examiners appointed by the College and approved by the National Council. Faced with this responsibility the College has had to do a good deal of educational re-thinking. Further, an attempt has been made to liberalize the curriculum as far as possible by introducing additional subjects such as English and social studies, and much thought has been given to the teaching of some of the aspects of science, including its history, method and philosophy which do not often find a place in lecture courses. All this should react on the teaching of the technological subjects, for these too can be the means to a liberal education if wisely and properly used.

Much yet remains to be done, and much that is planned needs to be carried to fruition, but the general liberating influence on the Colleges cannot be doubted.

RESEARCH AND POSTGRADUATE COURSES

Research has been undertaken in some Technical Colleges for many years, but in the main it has been restricted to a few of the larger colleges. It is intended that facilities should be expanded, particularly in Colleges of Advanced Technology. Students in these and other colleges will work for the new award higher than the Diploma in Technology, which the National Council for Technological Awards has decided to institute. For this purpose in May, 1959, the Council established the College of Technologists, and the new award is to take the form of Membership of the College of Technologists (M.C.T.). The award is intended to be a mark of outstanding distinction granted to a student for a programme of original work satisfactorily carried out jointly in industry and at a technical college, and extending over a period of some three years. A few students have already registered as candidates and the first awards are likely to be made in 1962.

In addition to research, some Colleges provide courses of lectures on advanced topics, including recent developments in science and technology. These are attended by large numbers of graduates, and seem to meet the needs of many scientists and technologists in industry.

Bulletin of The Institute of Physics and The Physical Society

The influence of professional institutions on education in Great Britain

By NORMAN CLARKE
B.Sc., F.Inst.P.

The Institute of Physics and The Physical Society

[A paper prepared for the International Conference on Physics Education held in Paris, July-August, 1960]

There are many ways in which the educational system of Great Britain differs significantly from those of other European countries and of America; not the least of these is the extent to which authority, both academic and administrative, is diffused. We are for example, one of the few countries in the world where the Ministry of Education carries no responsibility, financial or otherwise, for the Universities. In our rather loose, flexible but nevertheless confusing system the professional institutions are able to play a considerable part, particularly in relation to technical and technological education. As far as I know, there is no other country in which practising scientists and engineers—among many other professional groups—are so effectively able to bring their knowledge, experience and opinion to bear upon the way in which new entrants to their professions receive their training. I shall be concerned in this paper almost entirely with the way in which this affects education in physics, but similar considerations apply in other fields and, indeed, have usually applied for a much longer time since physics is comparatively new as a separate profession.

It is perhaps desirable to consider first the nature of the professional institutions themselves. The term is not precisely defined, but, in general, a professional body is a society of which membership is restricted, either wholly or mainly, to those who can provide evidence of competence in the practice of the profession for which the organization exists; its object is the advancement of a science, art or technology. The means by which this object is pursued include the usual functions of a learned society, such as the publication of journals and the organization of lectures and conferences, but responsible professional bodies consider that the restriction of their membership to those producing evidence of professional competence is in itself a means of advancing the subject for which they exist. Almost invariably the institutions lay down conditions which an applicant must satisfy in claiming professional competence, and these would normally include stipulated training and the passing of appropriate examinations. Nevertheless, the British—and especially the English—have always had an extremely healthy suspicion of those who place too much emphasis on examinations. Most professional bodies give themselves some freedom to accept exceptional people who do not comply with the normal educational requirements, but who have demonstrated over a period of years their professional competence in a high degree. Similarly, few of the professional organizations would regard the passing of an examination as, in itself, an adequate indication of ability; it is usual to attach considerable importance to evidence, including published papers, of a period of professional experience of suitable quality. For The Institute of Physics,* for example, a successful applicant for Associateship (the junior of the two professional grades) will have had about five years experience after graduation. Anyone elected to Fellowship will very rarely have less than ten years and usually appreciably longer.

An important part of the work of most of these institutions consists of the organization of their own examinations as evidence of the required standard of academic knowledge from which appropriate (but not all) university degrees would give exemption. In some professions, notably accountancy and architecture, the professional qualifications represented by membership of the appropriate professional body are of far more importance than a university degree, while there are others, particularly the law, where the examinations of the profession itself are necessary licences to practise, even for the university graduate in the subject. In general, membership of one of these institutions, in a grade which clearly carries with it the profession's own recognition of competence, is valued—especially outside academic circles—as indicating competence to *do* things rather than ability to *write* about things in university examination papers. No doubt this owes something to the British preference for the practical rather than the theoretical.

Although the status and influence of the better-known professional institutions are important factors in sustaining their membership, there are entirely different but equally important factors which should not be lost sight of. All these bodies impose upon their members individually, and seek to exercise for their members corporately, a sense of responsibility towards the community and towards their subject. Not only do they require members to behave according to a code of professional conduct, but much, indeed most, of their corporate activity is aimed at the public good, through the preservation of standards of qualification, practice and behaviour, and includes the provision of advice to official organizations and industrial and other concerns that regularly seek it.

In educational matters the influence of the professional institutions rests on two foundations. The first has been

* This paper was issued before the amalgamation with The Physical Society.

referred to above, namely their ability to stipulate what educational qualifications and training they will accept for membership. The second is the widespread recognition in official and unofficial circles that, in general, the professional institutions can command a unique degree of expert knowledge and judgement on their particular subjects and that these qualities should be brought to bear on decisions affecting the training of new entrants to the professions. In England we still respect achievement. Engineers who are actually building bridges and power stations, architects who are designing cathedrals or multi-storey buildings, and accountants who are in highly successful private practice or in control of the financial affairs of large corporations, equally with those who have successfully taught the respective subjects in universities and colleges for the whole of their professional lives have a real and accepted opportunity of influencing professional training. No doubt in the course of time this attitude will become as well established in physics as it is in engineering or accountancy ; a good deal of progress had been made in this direction already.

Research of a fundamental nature is, and will no doubt continue to be, that activity of physicists which is held in highest esteem. But with the great increase in the number of physicists which has taken place in the last fifteen years or so, only a small proportion is engaged in this way. Most British graduates in physics are working, and in future will work, in industry or Government service. Few of these will be primarily concerned with basic research. Gradually it is being recognized that our educational system must take some account of this fact, even though one hopes that the ultimate loyalty of physicists will always be to physics itself and that this loyalty will always recognize the special place of fundamental research in the subject.

The Institute of Physics has a membership which, except for teachers of the subject in schools, is fairly well representative of the profession as a whole. Its members range from those who have just qualified academically to those whose names are internationally known; some of them are university professors, some are directors of large industrial firms, some are young university research students, some are concerned with the control of industrial processes. If the views of physicists as a whole are relevant to educational policy in the subject, the Institute is in a special position to express these views. In fact, it does so in various ways and with varying degrees of effectiveness, and increasingly its views are not merely proffered but sought.

In any formal way the Institute has been much less concerned with education in the universities than with technical and technological education, for reasons which will be mentioned below. However, it has made some direct attempt to comment upon physics education in the universities as well as indicating indirectly, through its lists of acceptable university qualifications for membership, what it believes to be the appropriate university degrees at which students should aim. Some years ago it published a report on the education and training of physicists which was later replaced by *The Scientific Education of Physicists*. This is intended to give guidance to potential university students of physics in Great Britain. A few thousand copies of this are distributed free of charge each year. Towards the end of the war a joint committee with the Mathematical Association published *The Teaching of Mathematics to Physicists* and there is clear evidence that in at least some universities it has influenced considerably the courses in mathematics provided for specialists in physics. Recently the report was considerably revised by another small committee and has been re-issued in quite a different form in which it is hoped it will still be of value. Within the last few months has appeared the report of a committee which was set up jointly with The Physical Society to investigate the postgraduate training provided in the physics departments of British universities. This report, *The Postgraduate Training of Physicists in British Universities* is perhaps specially significant for the severe criticism of the quality of Ph.D. graduates which it records as having been expressed by leading industrial and government scientists.

It is in fields of education outside the universities that the professional bodies have mainly been active. We are now so accustomed to able children passing through the universities into the professions that we may fail to realize how small has been the contribution of the universities to the education of those professional men on whom so much of our civilization depends. Comparatively few practising solicitors are university graduates and perhaps even fewer of our leading accountants; even a substantial proportion of medical men are not graduates, and substantially less than half of the qualified engineers in Britain have had any contact with universities whatsoever. By the end of the 18th century our two ancient universities had virtually ceased to have any concern for the training of entrants even to the professions of law and medicine, and it was not until the rise of our newer universities, about a hundred years ago, that once again professional training came to be considered to be one of the functions of a university. Professional bodies began to carry, and continued to develop, the responsibility of examining for professional competence and this is the reason why almost all of them still exercise an influence mainly outside the universities. The situation is changing but even so is changing fairly slowly.

In physics the position is different since it is only recently that physicists have been regarded as people who could profitably be employed outside universities and schools. Until the second world war almost all professional physicists were university graduates, but since the war the changed status of the physicist, in that he is beginning to challenge the dominance of the engineer and the chemist in industry, has led on the one hand to the devising of methods of training professional physicists in non-university institutions and, on the other hand, to a greatly increased concern for the training of physics technicians. It is in both these fields that The Institute of Physics has been able to play a part of some influence. Immediately after the second war, when the universities were crowded with the return of those whose studies had been interrupted by war service, many of our tech-

nical colleges experienced a substantial demand for courses of university standard from those who were unable to secure admission to the universities. At that time there were almost no technical college courses of this standard which differed in any significant way from the conventional university course; the general practice was to prepare students for the "external" degree of the University of London. It is perhaps necessary here to explain briefly the nature of this qualification and also to explain the function and character of the technical colleges that were concerned.

The University of London is an unusual institution. It is, in fact, essentially an examining body, and it examines not only the large number of students who study in recognized university institutions for the "internal" degree, but it will also examine anybody who complies with somewhat minimal requirements. Although some Faculties of the University now impose regulations concerning study, in pure science, including physics, a candidate may present himself for a degree examination without ever having been in a properly equipped laboratory in his life. Various "cramming" and postal tuition organizations make a profitable business out of the preparation of candidates who may never have attended lectures by competent teachers, and the services of these bodies include advice on how to pass the practical examination with the minimum worry and preparation. The external degree system has its critics, but there are many who defend it.

Technical Colleges in Britain range from small institutions with a full-time lecturing staff of a dozen or fewer, up to those which are bigger than some of the universities. Almost all of them began as a means of meeting the demand for part-time further education from those who were working in industry. In general, the smaller institutions are primarily concerned with craft courses while the larger ones have a wide range of courses, some of them full-time, in science, engineering and possibly some other subjects such as management or architecture. Perhaps more than half of the 600 colleges of further education would offer some science courses of a fairly elementary kind but there are probably fewer than one hundred colleges which have any facilities in physics which would allow them to offer courses for even small numbers of students up to anything approaching degree level. At the end of the second world war there were far fewer colleges with such facilities but a very large programme of expansion and new building has been undertaken. In the last five years, for example, about seventy million pounds has been allocated for new technical college buildings in England and Wales alone, and there is every expectation that a similar programme will be carried out in the next five years. Among the many problems confronting technical education in Britain at the present time, availability of money is not one. Whether the money has always been wisely spent may be another matter.

At the end of the war colleges throughout the country were offering or trying to develop courses for the external degree of the University of London. In science this usually meant that they attempted the General degree which at the time had a three-subject final examination, and the subjects usually favoured were physics, chemistry and pure mathematics. Many of these courses ought never to have begun, and I can speak from personal knowledge of colleges where laboratory facilities were poor, the equipment grossly inadequate and the staff of doubtful competence, but where students were prepared, or at least presented, for the London degree. With a touching but unmerited faith in the infallibility of its own examiners, the University of London did not consider that any action was called for on its part. The Institute of Physics, prompted by some of its members who were engaged in technical college teaching or administration, felt that some action should be taken, and early in 1947 the Board of the Institute decided that it would in future recognize for its membership purposes only those external degrees that had been obtained after an approved course of study in a technical college recognized specifically for this purpose by the Institute. Except for a small number of colleges which were recognized immediately, recognition was to be granted only after inspection by representatives of the Institute. The Institute, of course, has no right of entry to technical institutions and its inspection could therefore take place only at the request of college Principals who wished their colleges to have Institute recognition.

In fact, the response from colleges has been extremely gratifying and more than 60 colleges are now approved for this purpose by the Institute. Our representatives who have visited colleges have never adopted a censorious attitude, and even when the facilities have fallen well below an acceptable standard their aim has been to draft recommendations to the governing body that would represent not only what was necessary but what was feasible. With trivial exceptions colleges have welcomed these recommendations and governing bodies have been willing to spend considerable sums of money on new equipment, new laboratories and on new appointments of better-qualified staff. Colleges have often been recognized initially for a period of only two or three years so that further visits could be made to see how far recommended improvements have been made. Usually three representatives of the Institute visit a college; I have been one of the representatives on every visit that has been made in the past thirteen years, and usually one university or technical college physicist and one industrial physicist make up the party. Usually also, we are accompanied by one of Her Majesty's Inspectors of the Ministry of Education, who attends in an unofficial capacity to give us information that we wish to have. Here I should like to pay tribute to the attitude of the Ministry's inspectorate. Visits by Institute representatives might have been regarded as an unwarranted intrusion but, on the contrary, we have received every possible help and encouragement from the Ministry.

As a result of this and other work in technical education the Institute has built up close contacts with many colleges and various organizations concerned with technical education. It is represented directly on governing bodies of colleges, on advisory committees and on various joint organizations such as Regional Advisory Councils. The Institute is also asked for opinions and advice, sometimes officially but often unofficially, on many aspects of education from detailed topics such as

the planning of syllabuses to matters of policy and staff improvement.

There was a second reason why the Institute was profoundly dissatisfied with the situation in technical education at the end of the war. Not only were many of the colleges ill-equipped for the work that they thought they should undertake but there were strong differences of opinion about the way in which colleges should develop. In the last few years of the war and for some years afterwards there was considerable public discussion in education circles in Britain about the pattern of technological education. In 1948 The Institute of Physics published its report, *The Education and Training of Technologists* which was prepared in order to elaborate the Institute's objections to proposals that had been put forward in a report of the Parliamentary and Scientific Committee. At the time it had few allies even though a few very influential bodies shared its views. In general, we took the view that it was essential that a small number of technical colleges should be encouraged to evolve to a position of academic and financial autonomy comparable with that of the universities, providing courses of university standard but significantly different in content and approach from those of the universities. In fact, the broad policy eventually adopted by the Government was very similar to that which the Institute advocated, although the method of implementation leaves a good deal to be desired. As Dr. Topping explains in his paper,* one of the most important developments in technological education in Britain since the war has been the establishment of the Diploma in Technology the course for which is broadly of the kind that The Institute of Physics advocated in 1948 as the work which should be undertaken by the major technical institutions. Its nature is explained by Dr. Topping. From my point of view in this paper its significance is that every College of Technology which has started a course for the Diploma in Technology in Physics has applied to The Institute of Physics for recognition of the Diploma as giving exemption from the Institute's academic requirements for membership. The Institute's policy is to send representatives to the college to discuss the course with the teachers and to inspect the facilities. This is done quite independently of the Ministry of Education and of the National Council for Technological Awards, the body responsible for awarding the diplomas. Incidentally, the Institute is directly represented on the Board of Studies of the National Council. We have taken very seriously the opportunity which has been given to express to college authorities our views on the individual courses. I think that it is true to say that in every case the College has recognized the validity of the criticisms that have been made and has taken or is taking effective steps to implement the Institute's recommendations. Wherever a course has been approved by the Institute the condition has been imposed that the external examiners whom the college is obliged to appoint must be people acceptable to the Institute, which must be consulted before they are appointed. All except one of the external examiners at present acting for these diploma courses are, in fact, Fellows of The Institute of Physics and this is an important way in which the Institute is helping to establish a significant advance in our educational system.

Turning to the training of technicians, The Institute of Physics was actually the first professional body in Britain to establish an award for people of this kind. For some years before the war its Certificate in Laboratory Arts was the only qualification specifically intended for laboratory workers but a few years after the war the City and Guilds of London Institute, which is well known throughout the British Commonwealth and elsewhere for its examinations for craftsmen, established at the suggestion of The Institute of Physics, a technician's certificate which is suitable for workers in chemical, biological and other laboratories as well as physics laboratories.

Dr. Topping in his paper discussed at some length the nature of the courses for National Certificates in Applied Physics. The control and administration of these courses is entirely in the hands of a joint committee of the Ministry of Education and The Institute of Physics with, of course, the close collaboration of the technical colleges. The Institute carries out all that part of the administration which is concerned with academic standards and examinations and, as the permanent officer of the Institute concerned with education, I am secretary of the three joint Committees that cover England and Wales, Scotland and Northern Ireland. The Institute alone appoints assessors whose functions are similar to those of external examiners. In some respects the National Certificate scheme is the most important way in which the Institute has been able to express its views on technical college courses and technical college facilities. No course for the Higher National Certificate in Applied Physics is allowed to begin in any college until representatives of the Institute, accompanied by one of the Inspectors of the Ministry, have visited the college and approved its facilities. In a large number of colleges we have been able to obtain substantial improvements in laboratory space, equipment and staffing. Here again, I think it is right to stress the enlightened attitude of the Ministry of Education and the encouraging response from college authorities to Institute recommendations for improvement.

Finally, reference must be made to the Institute's own Graduateship examination which is broadly of the standard of an honours degree in physics. It can be taken by those who have not attempted to obtain any other qualification but who have followed an approved course of study in a technical college; most of the candidates, however, hold either a university degree which is not accepted as giving complete exemption or hold a Higher National Certificate in Applied Physics. In 1960 nearly 200 candidates took the examination ;* this number is about one fifth of the total annual British output of honours physics graduates. Only about 30 per cent of the candidates are successful but the examination does provide a route to professional recognition for those who have either not had the opportunity of taking a qualification giving complete exemption or have failed at the first hurdle of a university

* Published in this issue of the *Bulletin*.

* 331 candidates have registered for the 1961 examination.

degree. We believe that the papers set in our examination show some degree of originality and that they have had an influence on teaching and examining physics in technical colleges and perhaps in some universities.

Some of us in Britain attach enormous importance to the flexibility of our educational system and not least to the opportunity of "feedback" into our educational thinking and organization of the views and experience of professional men who are not themselves teachers. With the maintenance of a proper balance, such an arrangement can be extremely fruitful to all concerned. In other countries, where professional organizations are probably much weaker and where this impact on education is not possible, development along lines similar to the British pattern might be worthy of consideration.

Appeal for the Physics Trust Fund

The following donations or subscriptions were received between December 24, 1960 and January 23, 1961:

(*a*) From members

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The total received or promised by January 23, 1961 (including those previously announced) was :

	£
Gross value of industrial firms' covenants over seven years (including tax recoverable)	96,617
Single donations from firms	6,549
Total from Industry ...	103,166
Gross value of members' covenants over seven years (including tax recoverable)	4,276
Single donations from members	484
Total from members ...	4,760
GRAND TOTAL at January 23, 1961	£107,926

Reviews of Books

STRUCTURE AND CHANGE—AN INTRODUCTION TO THE SCIENCE OF MATTER

By G. S. Christiansen and Paul H. Garrett

London: W. H. Freeman and Co. Ltd. Pp. xv+608. Price 63s.

PHYSICS AND CHEMISTRY, A UNIFIED APPROACH. VOLUME I

By J. C. Hogg, C. L. Bickel and E. P. Little

London: D. Van Nostrand Co. Ltd. Pp. xi+374. Price 37s. 6d.

I used to feel that the proverb *quot homines, tot sententiae*, which is pretty obsolescent anyhow in these times, was outstandingly irrelevant in the case of physics textbooks from the United States. *Tot textbooks*, if you like; and for the benefit of the more affluent collectors, I would often review them in groups, singling out only the rare distinctive excellences for praise. But things have been changing considerably during the past few years, and the two volumes here reviewed are both constructive attempts at new presentations of physical science, which can be discussed together simply because they have the same underlying pedagogic thesis—that physics and chemistry should be taught as a united whole. They are thus not really *physics* textbooks in the ordinary sense at all.

Structure and Change is intended for the mature reader with no previous scientific knowledge, and while it is an excellent and carefully planned book with which no reviewer could find serious fault, it is really more suitable for the scientist (and particularly for the teacher) who wants a modern survey of the subject to which he can refer, and from which he can draw descriptive material. An historian with some scientific background would also find it profitable. It is divided into three sections, *The Mechanical View of the Physical World*, *The Electrical View of the Physical World*, and *The Modern View of the Physical World*; the analysis of the experienced scientist. The first section begins with the solar system, Kepler's laws, inertia and mass, and Newton's laws of motion—topics that make a rather difficult start; and then goes on to the atomic theory, valency, and the periodic table. It ends with a chapter on geophysics. Chemistry comes well into its own in the second section where, after the elementary phenomena of electricity and magnetism have been established (with modern examples) and the properties of the electron explained, the rest is ionic theory and electrochemistry. The third section deals with light, quantum theory, nuclear physics, and cosmology and astrophysics.

It is true that the order in mechanics is much the same as that of the P.S.S.C. course, which many people have applauded; but the latter does not start the mechanics until a later stage, which makes a difference.

If the sequence of topics has not chosen quite the easiest route to understanding, the same can be said of the style. For example, it takes nearly a hundred words, including two paraphrases in parenthesis, to explain that $\varepsilon = mc^2$ is an expression meaning that ε is equal to mc^2. The book would be easier to read if it were more concise. In short, it is an intelligently conceived book which must come very near to a professor's-eye view of an ideal course; and I wish I knew all that is in it. But it is a harder assignment for the reader than I believe the authors intended.

Physics and Chemistry is at a much simpler level, and is the first year of a two-year course in the united subject. It begins with simple measurements, the concept of energy, the electrical nature of matter, and the elements of current electricity. Next, atoms and their fundamental particles; hydrogen; the metals and the electrochemical series (with the Daniell cell, which cheered me no end); oxygen, valency, water, and *then* Dalton's atomic theory leading to weight-calculations in chemistry. Next, hydrostatics, kinetic theory, gas laws, and volume-calculations in chemistry. Then, heat, the mechanical and electrical equivalents, carbon and heat-calculations in chemistry. Finally, forces, elementary statics and kinetics, and Newton's laws of motion. The second year's course, of which the contents only are listed, is to comprise electrolysis, light and electromagnetic radiation, the periodic table, atomic and nuclear physics, the halogens, and carbon compounds. This first part is well written, and suitable for beginners; and it includes a number of the stock basic class experiments. I would suggest that anyone who had worked through this volume would be well equipped to get a good deal out of *Structure and Change*.

Physics and Chemistry does not, you can see, follow either a logical treatment or an historical treatment; it is an intelligibility sequence. There is no doubt that simple pictorial ideas of atomic structure are easier to grasp than the law of multiple proportions, and energy conversions are more intelligible than Newtonian mechanics. This is probably the way in which many elementary courses organize themselves, and it seems a very sensible approach. Two of the authors have been using it for twenty years, so it is based on thorough experience. I wonder what a teacher of chemistry in this country would make of it.

G. R. Noakes.

PRINCIPLES OF THE EXTRACTION OF METALS

By Dr. D. J. G. Ives

Monographs for Teachers No. 3, Royal Institute of Chemistry. Pp. 57. Price 6s.

This short monograph is one of the initial issues in a series designed to give general guidance on specific subjects to science teachers responsible for the preparation of candidates for Advanced Level G.C.E. examinations, and other similar tests. The Council of the Royal Institute of Chemistry has rightly felt such guidance to be helpful, particularly in respect of certain topics where difficulties arise in clear presentation in terms of fundamental principles. One such topic on which many text-books are somewhat unhelpful, is the extrac-

tion of metals from available raw materials. It is not unusual to find the extractive metallurgy of an element dealt with by means of a detailed description of the practice of an industrial process in a separate section at the end of a chapter on general chemistry, with the vital connections between science and practice only tenuously established, if at all. The strain on the student's memory is considerable, and his understanding is not developed. The present monograph shows that it is both possible and profitable to present a theoretical framework into which a large variety of industrial processes neatly fit. Provided that the student has an adequate background of physical chemistry he will be able to appreciate the general principles involved, and to understand, on the basis of these, exactly why industrial processes have assumed the particular forms he reads about in his text-books. The theoretical framework is inevitably based on thermodynamics, and the monograph serves a very useful purpose in relating thermodynamics immediately and intimately to practical operations; too often thermodynamics remains, in the student's mind, unconnected with physical and chemical realities.

The thermodynamic background of pyrometallurgy is well presented, and used as the basis for a criterion of the tendency of a given reaction to occur; the equally relevant kinetic factors are also, though less fully, considered. There are sensible and understandable discussions of entropy, free energy, chemical potential, and the working equations necessary for handling examples. These occupy but 8¾ pages, so that it will be appreciated that the treatment is condensed; it is, however, clearly intended as a guide to the teacher, who will be able to fill in whatever else may be needed by his pupils. The thermodynamics of pyrometallurgical processes are also discussed, with particular reference to " Ellingham Diagrams "—plots of standard free energy changes for given types of reaction (oxidation, reaction with sulphur and so on) against temperature. The importance of these is well emphasized, and sufficient examples of their use are given to form the basis of a good understanding of how a number of industrial processes are linked into a connected scheme. In a final chapter a selection of typical processes is considered, not in isolation, but as examples of the general principles previously discussed.

This monograph, which was made possible by the establishment of a Royal Institute of Chemistry Fund for Education in Chemistry is certain to be found useful by all science teachers who wish to present the subject, usually somewhat unattractive to students, in an interesting and scientific manner. They may need to fill it out in certain respects which their own experience will suggest, and they may find that the treatment demands more elementary thermodynamics than the average advanced level G.C.E. candidate will normally possess. Any effort needed to bring the pupil to an understanding of the material of this book will, however, be well worth while and well repayed. Both the author and the Royal Institute may be congratulated on the production of this inexpensive monograph.

G. V. Raynor.

PHYSIOLOGY OF THE RETINA AND VISUAL PATHWAY

By G. S. Brindley

London: Edward Arnold (Publishers) Ltd. Pp. xi + 298. Price 35s.

This book includes a general introduction to the subject and a series of essays on topics of special interest to the author. It is very welcome to research workers in Physiological Optics because it shows interesting relations between experimental results which are scattered through the literature. The interpretations given by the author are useful in themselves and valuable because they suggest new lines of thought to his readers.

A physicist who is beginning to study the subject will find this book useful but will need to supplement it by reference to other texts as well as to original papers. For example, he will need to consult the books of W. D. Wright for detailed information on colour vision.

I hope that in a later edition the author will have a good deal more to say about receptor fields, lateral inhibition and similar topics whose importance has become apparent since his text was written.

R. W. Ditchburn.

CLASSICAL DYNAMICS

By R. H. Atkin

London: William Heinemann Ltd. Pp. ix + 273. Price 30s.

This book deals with the subject as usually included in a mathematics honours course ; it is also claimed that " it will be an essential book to university students of physics, especially since it takes full account of examination requirements ". There are two main features ; firstly, it uses vector methods ; secondly, it sets out laudably to make clear the simple scientific foundations of the subject in the hope that readers will not get lost amongst a bewildering succession of examples. One doubts whether either of these is successful.

There is a useful chapter on vector algebra ; the old cross notation is used for the vector-product, but the newer notation creeps in unexplained in one example (page 33). There is a mixture of cartesian and vector solutions ; indeed many problems are solved in the classical way and a vector treatment sometimes given as an alternative.

The book opens with a short chapter on " historical foundations " into which what might be called the physics of the science is compressed. It is welcome, but is it adequate ? And the specification of the gravitational law begins: " every body attracts every other body . . . ". Pages later we are told that the words " single body " may commonly be replaced by the word " particle ", and that " in one instance the particle might be as large as the earth and in another as small as the calculus requires ".

The later chapters of the book include Lagrange's equations for a general system, the general motion of a rigid body and gyroscopic problems. There are many exercises which are taken from examination papers of the University of London and of the Mathematical Tripos, and also from Love's book on Theoretical Mechanics.

J. Topping.

PRINCIPLES OF ELECTROLYSIS
By C. W. Davies
Monographs for Teachers No. 1. Royal Institute of Chemistry. Pp. 30. Price 3s. 6d.

PRINCIPLES OF OXIDATION AND REDUCTION
By A. G. Sharpe
Monographs for Teachers No. 2. Royal Institute of Chemistry. Pp. 30. Price 3s. 6d.

The Royal Institute of Chemistry has had the excellent idea of publishing a series of *Monographs for Teachers* which will give " . . . concise and authoritative accounts of selected well-defined topics in chemistry for the guidance of those who teach the subject at G.C.E. Advanced Level and above." The scheme has started well with the first two issues by Professor Davies and Dr. Sharpe.

One would expect excellent expositions by two such distinguished authors but one might wonder whether they would strike the right level for VIth forms. It is the opinion of this reviewer that they have succeeded admirably and have also handled their subjects in a way which should excite readers to enquire further. For example they introduce ideas of polarization and over-potential, draw attention to the effect of ionic diffusion in electrolysis, and discuss the theory of many of the volumetric exercises practised in VIth forms to-day. Particularly useful are Dr. Sharpe's references to the realms of thermodynamics and kinetics, i.e. the treatments of the two questions how far and how fast can a process go. The distinction between these two questions, which must be constantly reiterated to every student of chemistry, is underlined, e.g. by Dr. Sharpe's discussion of the oxidation of thiosulphate to tetrathionate instead of to sulphate. The final words of this same monograph should be inscribed in every student note-book " . . . one of the main aims of the study of science ; a knowledge not only of its powers but of its limitations."

As this series multiplies there will inevitably be some overlap but this is not a bad thing so long as the authors are agreed on conventions, symbols, etc. In the present monographs it is pleasing to see that both authors have used the same sign convention for electrode potentials, and that Dr. Sharpe has given such a clear exposition of the conventions in common use to-day.

Suggestions for improvement can of course be made. Some figures to illustrate some of the points made would have been useful ; for example, values of hydrogen over-potentials on various metals, values of thermal velocities to support the point that ionic velocities are small by comparison (Prof. Davies, p. 5). The usual statement that electrolytes obey Ohm's Law could perhaps be related to the section on p. 17 where decomposition voltages are mentioned. On p. 10 a footnote " see Appendix for sign convention " would help the reader.

E. G. Cox.

MATHEMATICS EDUCATION AND INDUSTRY
A Conference of Teachers, Research Scientists and Industrialists at the University of Liverpool, April, 1959. *London : " Technology ". The Times Publishing Co. Ltd. Pp. 156. Price 7s. 6d.*

It is indicative of the increasing employment of mathematicians in industry that after the successful Oxford Mathematical Conference in 1957, the University of Liverpool should have arranged another conference of teachers, research scientists and industrialists at Easter, 1959. A record of this Conference has now been published, which will interest many teachers in schools and technical colleges. It contains a summary of the papers read at the Conference, many of which were contributed by industrial scientists and gives a glimpse of the kind of problems that have arisen in electrical engineering, chemical engineering, atomic energy, the aircraft industry, biological and agricultural research, as well as in insurance, textiles and operational research.

The Conference was exercised as to how this should affect the teaching of mathematics in schools and consequently the education of mathematicians. Members of the Education Group of the Institute and readers of the *Bulletin* will not be surprised that there was a recurring emphasis on the teaching of numerical methods, of statistical techniques (and not merely the arithmetic involved), of approximations and iterative methods, and of the supreme importance of aiding students to appreciate the nature of a mathematical model and to formulate problems in mathematical form. All this calls for imaginative teaching, and for changes in the content of courses in schools, technical college and universities. It was good that the Conference was reminded of Bickley's musings when he wondered " if it is an exaggeration to say that those who teach the youngest children do not know enough mathematics, while those who teach the sixth form know nothing else ".

But besides differently educated mathematicians we need more, particularly in schools. Sir Gilbert Flemming, formerly head of the Ministry of Education, in his review of the measures needed to provide the mathematical specialists likely to be required in the next ten years could only say " staffing is bound to continue difficult and many schools will have to resort to expedients. We should all encourage and help the employment of part-time teachers, particularly married women. . . . " What *are* we going to do ?

J. Topping.

Notes and News

New Year Honours list

In the New Year Honours list knighthoods were conferred on Professor A. C. B. Lovell, O.B.E., F.Inst.P., F.R.S., and Dr. A. H. Wilson, F.Inst.P., F.R.S.

Rheological Techniques

The British Society of Rheology and the Non-Destructive Testing Group of the Institute and Society will hold a joint meeting on this subject at Llandudno on September 21 and 22, 1961. The aim of the meeting will be to discuss rheological techniques in detail. Usually in the presentation of a paper discussion of experimental results is given at the expense of the description of the techniques. It is intended that on this occasion the opposite will be true. The proceedings of the meeting will be published in special issues of *Laboratory Practice*. Contributions to the meeting are invited, and intending speakers should write to Dr. M. F. Culpin, F.Inst.P., 8 The Broadway, Pontypool, Monmouthshire, as soon as possible.

Professional conduct

A sub-committee of the Membership and Education Committee is considering the formulation of a code of professional conduct to replace that quoted in By-law 62. Any Fellow, Associate or Graduate of The Institute of Physics who wishes to submit his views or to draw the attention of the sub-committee to any professional matter to which, in his opinion, the code should specifically refer, is invited to send *written* comments to the secretary of of the sub-committee, Mr. Clarke, at Belgrave Square.

Visitors to Australia

The Secretary of the Australian Branch has asked to be kept informed of impending visits by members to Australia so that they may be advised of activities of the Branch and its Divisions of which they might wish to take advantage. He would also be happy to give assistance or advice in the planning and organization of such visits. Members contemplating visiting Australia are therefore invited to inform the Secretary of the Institute and Society at headquarters, giving as much advanced information of places likely to be visited as possible.

THE INSTITUTE OF PHYSICS AND THE PHYSICAL SOCIETY EDUCATION GROUP

EASTER CONFERENCE ON

COMMUNICATION

Physics for the non-specialist

April 6 and 7 1961

at

47 Belgrave Square, S.W.1

Accommodation is limited. Enrolment forms are available from the Administration Assistant of the Institute and Society and should be returned as soon as possible.

A Conference sponsored by

THE INSTITUTE OF PHYSICS AND THE PHYSICAL SOCIETY

on

PALAEOMAGNETISM

is to be held at

KING'S COLLEGE, UNIVERSITY OF DURHAM, NEWCASTLE-UPON-TYNE

from 20-22 April, 1961

Main topics will be :

Geophysical objectives in world-wide palaeomagnetic surveys

Methods for removal of secondary magnetization from lavas and sediments

The application of Neel's theories to rock magnetism

Comparisons of inferences from palaeoclimatology and palaeomagnetism

Registration is necessary and programs and application forms are available from

The Administrative Assistant, Physics Department, King's College, Newcastle-upon-Tyne, 1

Branch and Group Committees

The Committees of the Institute and Society's Branches and Groups in Great Britain are at present constituted as follows:—

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Dr. G. M. Leak, F.Inst.P.
Dr. J. G. Rider, A.Inst.P.
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Dr. G. S. Parry, A.Inst.P. (Co-opted)
Dr. B. M. Rimmer
Dr. J. C. Speakman
Dr. H. P. Stadler, A.Inst.P.
Dr. E. G. Steward, F.Inst.P. (*Hon. Sec. Equipment Sub-Committee*)

Symposium on Electrical Contacts

The Institute and Society in collaboration with The Institution of Electrical Engineers is arranging a symposium on "Electrical contacts" to be held at Brunel College of Technology, London, on April 5 7, 1961.

Topics will include:

Electrical erosion and material transfer

Mechanical wear

Influence of surface films and contamination

Make-and-break contacts.

Sliding contacts

Semi-permanent contacts and connexions between metallic and non-metallic materials.

Major interest will be focused on contact resistance.

The Symposium is intended mainly for persons concerned with the design and improvement of contacts.

There will be a small informal exhibition.

Registration is necessary.

Programs and enrolment forms are available from The Secretary of the Institute and Society.

A Nuclear Physics Conference

is to be held in

The University of Birmingham

April 17, 18 and 19, 1961

This Conference will be sponsored by The Institute of Physics and The Physical Society

It is proposed to devote sessions to the following:—

(i) γ-ray scattering

(ii) Low energy nuclear reactions nuclear models

(iii) Instrumentation and machines

(iv) Nucleon-nucleon and nucleon-nucleus high energy physics

Registration is necessary.

Programmes and application forms are available from the Conference Secretary, Department of Physics, The University, Edgbaston, Birmingham, 15.

Forthcoming Institute and Society Meetings

Date	*Place*	*Speaker*	*Title and other details*	*Time*	*Branch or Group*
Feb. 15	**Birmingham** Birmingham Exchange and Engineering Centre	Dr. J. Darbyshire, F.Inst.P. (*National Institute of Oceanography, Wormley, Surrey*)	**Sea waves and microseisms**	6.30 p.m.	Midland
Feb. 17	**Cheltenham** North Gloucestershire Technical College	Mr. D. F. Gibbs, A.Inst.P. (*University of Bristol*)	**Physics of musical instruments**	7.00 p.m.	South Western
Feb. 20	**Edinburgh** The University	Dr. W. M. Lomer (*United Kingdom Atomic Energy Authority, Harwell*)	**Magnetic susceptibility of transition metal alloys**	7.15 p.m.	Scottish
Feb. 20	**Feltham** National Physical Laboratory, Ship Hydrodynamics Laboratories	Mr. J. R. Shearer	Visit to the Ship Hydrodynamics Laboratories including a talk on **Dynamometer techniques used in ship model research** Registration is necessary.	2.30 p.m.	Stress Analysis
Feb. 20	**Newcastle-upon-Tyne** King's College	Dr. J. A. Chalmers, F.Inst.P. (*University of Durham*)	**Thunderstorm theories**	6.15 p.m.	North Eastern
Feb. 20	**Manchester** The University	Dr. L. Essen, O.B.E., F.R.S. (*National Physical Laboratory, Teddington*)	Branch Annual General Meeting followed by a lecture on **Some misconceptions concerning the special theory of relativity**	6.30 p.m. 7.00 p.m.	Manchester and District
Feb. 21	**Glasgow** The University	Dr. W. M. Lomer (*United Kingdom Atomic Energy Authority, Harwell*)	**Magnetic susceptibility of transition metal alloys**	7.15 p.m.	Scottish
Feb. 23	**London** Headquarters	Mr. B. G. Browne (*University of Cambridge*)	Branch Annual General Meeting followed by a lecture on **The earth's gravitational field**	2.30 p.m.	London and Home Counties
Feb. 24	**Cardiff** University College	Professor J. Rotblat, F.Inst.P. (*Medical College of St. Bartholomew's Hospital, London*)	**Nuclear physics in medicine**	6.15 p.m.	South Wales
Mar. 1	**London** Headquarters	Dr. W. A. Wooster, F.Inst.P. (*University of Cambridge*)	**Crystal symmetry—old and new**	6.30 p.m.	X-ray Analysis
Mar. 2	**London** Imperial College	Mr. A. E. Crawford (*Brush Crystal Co. Ltd., Southampton*)	**Zirconate-titanate materials for ultrasonic transducers**	5.30 p.m.	Acoustics
Mar. 2	**London** Institute of Marine Engineers	Speakers to be announced later	**Problems of thermal insulation and their solution**	2.00 p.m.	Low Temperature jointly with the Institute of Refrigeration
Mar. 2	**Leeds** The University	Professor J. D. Bernal, F.Inst.P. F.R.S., (*Birkbeck College, London*)	Branch Annual General Meeting followed by a lecture on **Geometrical aspects of physical theories**	7.30 p.m.	Yorkshire
Mar. 4	**Manchester** Grammar School	Introduced by Lord James (*Manchester Grammar School*), and Mr. A. D. C. Peterson (*University of Oxford*)	Discussion on **specialization at school** including a tour of Manchester Grammar School	10.00 a.m.	Education jointly with Manchester and District
Mar. 9	**Liverpool** The University	Dr. N. B. Slater (*University of Leeds*)	**Fundamental theory**	7.00 p.m.	Liverpool and North Wales
Mar. 10	**Bristol** The University	Professor O. R. Frisch, F.R.S. (*University of Cambridge*)	**The conservation laws of modern physics**	7.00 p.m.	South Western
Mar. 10		Lecture and details to be announced later			Non-Destructive Testing

Date	*Place*	*Speaker*	*Title and other details*	*Time*	*Branch or Group*
Mar. 14	**London** Headquarters		Group Annual General Meeting followed by a lecture on	5.30 p.m.	Electronics
		Dr. O. S. Heavens, F.Inst.P. (*Royal Holloway College, London*)	**Optical masers**	5.40 p.m.	
Mar. 15	**London** Beveridge Hall		Symposium on **Soil**	2.30 p.m.	London and Home Counties jointly with the Royal Institute of Chemistry and the Institute of Biology
		Registration is necessary.			
Mar. 16	**London** Headquarters		Group Annual General Meeting followed by lectures on	2.30 p.m.	Optical
		Mr. D. G. Demaine (*Hilger & Watts Ltd.*)	**The use of very fast digital computers in optical analysis and correction**		
		Dr. A. Goodman (*Birmingham College of Advanced Technology*)	**A theory of differential analysis for the correction of optical systems**		
Mar. 17	**Swansea** University College	Dr. R. A. Smith (*Royal Radar Establishment, Malvern*)	**Recent advances in physics of semiconductors**	5.15 p.m.	South Wales
Mar. 20	**Manchester** College of Science and Technology	Professor B. H. Flowers (*University of Manchester*)	**The structure of neutrons and protons**	7.00 p.m.	Manchester and District
Mar. 21	**Glasgow** The University	Dr. O. S. Heavens, F.Inst.P. (*Royal Holloway College, London*)	**Optical masers**	7.15 p.m.	Scottish
Mar. 21	**Newcastle-upon-Tyne** King's College	Dr. P. B. Hirsch, A.Inst.P. (*University of Cambridge*)	**Electron microscope studies of dislocations in metals**	6.15 p.m.	North Eastern
Mar. 22	**Birmingham** James Watt Memorial Institute	Dr. J. H. Davis, F.Inst.P. (*Bradford Institute of Technology*)	**Electronic reading machines**	6.30 p.m.	Midland
Mar. 22	**St. Andrews** St. Salvator's College, St. Andrews University	Dr. O. S. Heavens, F.Inst.P. (*Royal Holloway College, London*)	**Optical masers**	5.00 p.m.	Scottish
Mar. 23	**Aberdeen** The University	Dr. O. S. Heavens, F.Inst.P. (*Royal Holloway College, London*)	**Optical masers**	7.45 p.m.	Scottish

Manuscripts accepted for publication in the Institute and Society's periodicals

The following abstracts are of papers accepted up to the end of December. The lists are not quite complete due to the change in system, as stated in last month's *Bulletin*. They should be fully up-to-date by next month.

British Journal of Applied Physics

Method for the consistent transformation of physical equations into non-dimensionally parametric form. By J. C. Amon.

Necessary and sufficient conditions for the existence of a simplifying transformation of a set of physical equations are given, whereby the physical variables involved become a less numerous set of dimensionless parameters. The proof provides a method for performing this transformation and for deciding whether it is unique, and this method is described. Whilst such a transformation is always possible for a single physical equation whose form is algebraic, its existence and description is not always apparent when more than one such algebraic equation is affected and the transformation is required to apply consistently to each; or when the equations are not algebraic. The method described is applicable not merely to sets of general equations, but to any collection of power-products of physical variables whose consistent transformation is desired.

Measurement of thickness of thin transparent films using fluorescence. By B. P. Bunt.

A molecular fluorescence method of comparing the thickness of transparent films (in the range 3×10^{-6} to 10^{-5} cm) is described. An instrument for use in the middle of this range (10^{-6} cm) is also described and results show that its accuracy is to better than $\pm 2\%$.

The determination of stress concentrations with an electrolytic tank model. By T. W. G. Calvert.
In a loaded lamina of complicated shape stress concentrations arise which it is difficult to calculate. A model in the form of an electrolytic tank may be used to find the resultant stress at any point in a loaded lamina. The tank is made of an insulating material to the same shape as the lamina and filled with an electrolyte. It is fitted with electrodes to represent the areas over which the load is applied. The loads are represented in magnitude by the alternating currents flowing through the electrodes and in direction by the relative phase angles of the currents. The electric current at any point in the model tank can be sampled with a probe consisting of two fine wires a short distance apart. The resultant stress at a point in the loaded lamina is proportional to the electric current at the corresponding point in the model tank. This approach offers a valuable addition to means already available for finding stress concentrations in laminae of complicated shape.

The electromechanical coupling factor of piezoelectric ceramic discs. By D.S. Campbell and A. M. MacSwan.
Numerous formulae have been given for the calculation of the electromechanical coupling factor of piezoelectric discs in terms of the resonant and antiresonant frequencies. These formulae, which are derived either on the basis of an analysis of the mechanical motions of a disc, or by considering the equivalent electrical circuit, give widely divergent values of coupling factor. It is shown that when an equivalent circuit which takes account of the overtones is used, the corresponding value of coupling factor obtained is in agreement with that of the mechanical analysis. Curves, and a nomogram are given to enable coupling factor to be quickly calculated from the equations of the mechanical analysis without approximation.

Capillary viscometers of negligible kinetic energy effect. By W. A. Caw and R. G. Wylie.
By incorporating capillaries with long-flared ends in otherwise conventional U-tube or suspended-level viscometers, it is possible to produce instruments in which no significant kinetic energy effect occurs for the Reynolds numbers generally encountered in viscometry. A detailed experimental study of their behaviour has been made. Using the new viscometers a viscosity scale in absolute units can be established with greater accuracy and greater facility than has hitherto been possible.

Fields external to open-structure magnetic devices represented by ellipsoid or spheroid. By H. Chang.
The mathematical expressions for the field intensities external to spheroids or an ellipsoid with uniform magnetization are given. They are useful in predicting fields external to (*a*) open-structure magnetic devices such as metallic or ferrite films, twistors or splinters, and (*b*) spheroidal and ellipsoidal samples which are often used in magnetic measurements.
Curves are plotted to indicate the spatial variation of field intensity with the dimensional ratio of a spheroid as a parameter. In the region near the spheroid, field intensity is normalized against field intensity at the boundary. In the region far from the spheroid, field intensity is normalized against that of a dipole of the same dipole strength as the spheroid.

Technique for the rapid, accurate and strain free machining of metal single crystals. By M. Cole, I. A. Bucklow and C. W. B. Grigson.
Spark planing, a new spark erosion method for the production of flat smooth metal surfaces, is described and its application to single metal crystals and to metallographic preparation is discussed. The use of conventional spark erosion methods for crystal cutting and forming is also described. The spark planing technique is far more rapid and accurate than chemical or electrochemical machining and it causes very much less damage to the surface than the most careful grinding operation. Spark planed surfaces have been examined by x-ray diffraction, reflection electron microscopy and a Talysurf tracer; these results are presented and the nature and extent of surface damage to various metals is discussed.

An assessment of the accuracy of 'flying spot' scanning for the measurement of microscopic particles. By C. G. L. Furmidge.
A critical review has been made of the reliability and accuracy of 'Flying Spot' scanning for the automatic measurement of microscopic particles. The instrument used was the Flying Spot Particle Resolver manufactured by Messrs. Rank Cintel Limited. Most of the results quoted were obtained using a reflected light scanning technique for the measurement of spray droplet stains but it is probable that the conclusions may be applied to the measurement of many other types of microscopic particles. The possible errors associated with automatic methods of measurement have been considered under the headings (*a*) Errors inherent in the design of the instrument, (*b*) Errors which are due to faulty operation of the instrument, (*c*) Errors which are due to the nature of the sample being measured. The accuracy and reliability of the automatic assessment of particle size has been compared with the visual assessment using a standard optical microscope. It is concluded that the speed and reliability of automatic measurement are considerably greater than can be achieved by visual measurement. Basically the instrument is very accurate, but the accuracy with which a particular sample is assessed depends to a considerable extent on the nature of the sample. Inaccuracies are introduced by overlapping or aggregation of the particles on the sample, by irregular shaped particles and by the absence of well defined, clear cut edges to the individual particles on the sample. The importance of these possible inaccuracies is discussed.

Heating of metallic foils in an electron microscope. By B. Gale and K. F. Hale.
The temperature of a thin metal foil illuminated by the high intensity electron beam of the modern microscope may at the centre of illumination reach a temperature above that of the melting point of the foil. An attempt has been made to measure and calculate the temperature distribution for any given metal under various illumination conditions and to determine also the stress fields produced in the foil by such temperature distribution.

The colour-temperature of an incandescent helical filament. By J. E. Gibbs and G. W. Gordon-Smith.
Spectrophotometric measurements at 0·54 and 0·69μ of the radiation from the 'inside' and the 'outside' of the helical filament of a 12v, 48w car bulb run at 4λ show that, owing to multiple reflection within the helix, the luminance of the inside is about 70% greater, and its colour-temperature 50 ± 1 deg K lower, than that of the outside. The colour-temperature of the integrated light from a helical filament depends critically on the angular position of the receiver relative to the source. Irregular variations of about 10 deg K have been measured within ±10° of the equatorial plane of the filament mentioned, and similar variations for a 100v, 500w uniplanar projection lamp. Caution is indicated in using such lamps as standards of colour-temperature.

Internal friction in fibre assemblies. By J. D. Huffington.
Experiments have been carried out to measure the energy dissipated as internal friction (hysteresis loss or work of deformation) when sliding rectangular steel sliders on various types of fibre assembly. The theoretical assumptions previously made by Greenwood and Tabor in explaining experiments with steel balls sliding on rubber lead to predictions of internal friction in fibre assemblies which are too low. It is thought that one reason for this is the tendency for the pressure to build up at the front edge of the slider when it moves over a fibre assembly, thus increasing the amount of internal friction corresponding to a given deformation. It has also been found that the energy dissipated is abnormally high for staple yarns as compared with continuous filament yarns. It seems that two mechanisms of energy dissipation exist. On the one hand there is the normal mechanism where deformation is subject to complete elastic recovery although energy is lost in the process. In addition, with staple yarns in particular, work of internal rearrangement may occur which is not subject to elastic recovery, but which represents a permanent change in the yarn. It is suggested that this may be a wear or abrasion factor due to general sliding and loosening of fibres within the yarn. A quantitative measure of this factor offers an approach to a definition of abradability or liability to wear.

The preparation of thin films of germanium and silicon. By B. A. Irving.
Films about 1000Å thick, suitable for observing dislocations by transmission electron microscopy, have been prepared from the brittle semiconductors germanium and silicon by a combination of mechanical polishing and chemical etching.

Ultrasonic relaxation in polyatomic gases and vapours. By S. K. K. Jatkar and D. D. Deshpande.
The paper describes a simple method of calculating ultrasonic relaxation frequencies in polyatomic gases. The mechanism of relaxation is explained as a resonance phenomenon by assuming a characteristic rotational oscillation frequency of gas molecules in ground state, due to the interaction field of neighbouring molecules. Using infra-red vibration and electronic frequencies given by the ionization potential, in the relation $f = (2\pi) \times \sqrt{(3\Delta\mu a^3/4\mu^2)}$ the relaxation frequencies are evaluated for carbon dioxide, carbon disulphide, nitrous oxide, sulphur dioxide, ammonia, acetaldehyde, benzene, methane, and chloromethanes, and are in close agreement with the experimental data. The method is also extended to involve calculation of parameters such as partition functions and collision probabilities.

Porosity and surface area of a granular bed from measurements of the flow of air through the bed and measurements of the granular shape factors. By W. M. Jones and D. Mills.
Flow experiments give an equation relating ϵ to S in terms of measurable quantities, where ϵ is the inter-granular porosity of the bed, and S is the envelope surface area of the granules in 1 cm³ of bed. Heywood's shape factors for the granules give a second equation relating ϵ to S, and hence the two equations ϵ and S can be determined uniquely. If the tortuosity factor be taken to be $\pi/2$ in the equations given previously, connecting the friction factor λ and the Reynolds number R_e, then $\lambda = 16/R_e$ for granular beds, as for long straight tubes.

Conformal transformations by analogue computer. By E. J. Jones and D. S. Ross.
This paper describes the use of an analogue computer to generate certain conformal transformations of the circle, these being of use in the analysis of stress patterns in the neighbourhood of holes of various shapes. The relationship between the form of transformation and the shape produced is also discussed.

The frictional properties of lignum vitae. By K. G. McLaren and D. Tabor.
A study has been made of the frictional properties of lignum vitae, an extremely hard wood which finds an important application in underwater bearings. In the dry state, the friction of this material is comparable with that of P.T.F.E. and experiments show that this is due to the lubricating action of woodwaxes expressed from the wood during sliding. The rolling friction due to hysteresis losses is very small. The sliding friction can be explained satisfactorily in terms of an adhesion mechanism.

The significance of the properties of materials in the packing of real spherical particles. By J. C. Macrae and W. A. Gray.
Measurements of the packing of spherical particles poured into a cylindrical container show that the intensity of deposition, the height of drop and the elasticity of the particle material influence the packing equally. Minor departures from perfect sphericity tend to mask the influence of elasticity. Optimum packing of poured spherical particles occurs when the energy increment imparted to the bed by each impacting particle exceeds a critical value, the rate of renewed application of increments is above a critical value and the intensity of deposition is below a critical level. Within a critical range of deposition conditions, sufficient energy may be imparted to spherical particles to activate a process of ordered packing, initiated at a wall. These conditions are fulfilled when 0·125 in. diameter spheres fill a 3 in. diameter glass cylinder at 1400 particles per second with impact velocities greater than $120/\{\frac{1}{4}(1+e_w)\}^{1/2}$ in/s, being the resilience of the particle material. Determinations of wall effect show that these conclusions and the derived mechanism of packing are valid for the packing of an infinitely extensive bed.

SPECIAL ARTICLE

Design of scales for industrial instruments. By A. J. Maddock.
After discussion of the results of various experimenters on the errors that may arise when reading instrument scales and possible means of reducing

them, attention is given to recommendations being prepared by the British Standards Institution. Particularly important is the relationship between size of scale and reading distance and the correlation with this of sizes and spacing of the graduation marks and numerals. An analysis of possible scale ranges and the subdivision of these to proceed in number steps of 1's, 2's or 5's, shows that the number is limited and not all can conform to the desired optimum conditions of design; compromise is therefore necessary particularly in the degree of accuracy to which the scale may be read. The scale designs considered are suitable for industrial instruments having accuracies to the order of 1 to 2 %.

Investigation of periodic discontinuities in the mutual potential energy of molecules of water and some polyhydric alcohols. By M. M. Qurashi and A. K. M. Ashanullah.

The inter-molecular energy of activation of viscous flow has been measured at close intervals of 2 to 5 deg c for glycerol, ethylene glycol and thrice-distilled water, using the logarithmic derivative of the Andrade (1934) equation, namely,

$$\frac{\Delta \ln \eta}{\Delta T} = -\frac{(\epsilon/k)}{T^2}.$$

In the case of water and ethylene glycol, the temperature has been controlled to 0·002 and 0·005 deg c respectively, and the temperature intervals measured with a calibrated Beckmann thermometer. By maintaining a corresponding accuracy in the viscosity measurement, the values of ϵ/k for water are reproducible to 0·1 % in the temperature range from 6 to 45°c and to 0·3 % from 45 to 72°c. The results when plotted against temperature indicate a step-like variation of the energy ϵ, the repetition interval between steps being 25 deg c for glycerol, 12 deg c for ethylene glycol, and 6·5 ± 0·2 deg c for water.

The drop between successive steps in water is sharp, extending only slightly more than the measuring interval of 2 deg c, and each step is flat within the limits of experimental error. The energy interval $\Delta\epsilon$ between steps is not constant, but decreases steadily towards higher temperatures. The average value of this interval Δ_1 is of the order of 80 k.j., i.e. 0·007 ev, and much smaller than the thermal energy kT, but is of the same order as the fine structure observed in the OH absorption of water at 3300 cm^{-1}.

The temperature variation found for ϵ/k is compared with the graph calculated from the viscosity data of Bingham and Jackson (1918–19) on water, and fair agreement is obtained when the 2 deg c measuring interval of the present experiments is smeared out to 6 deg c.

The copper staining of p–n–p alloyed junction transistor sections. By S. Ratcliffe and J. E. Hughes.

A technique is described for the staining of germanium p–n–p alloyed junction transistors using chemical deposition of copper. It is shown that copper is deposited preferentially on p-type regions and, in so doing, reveals certain features associated with regrowth processes. Other structural effects which are revealed may be connected with strain induced in the semiconductor by thermal cycling.

Spectral emissivity of 99·7% aluminium between 200 and 540°c. By P. M. Reynolds.

Results are given for surfaces of roughness 3μ in., 115 μ in. and anodized aluminium within the wavelength range 1 to 14 μ. The spectral emissivity varied strongly with surface roughness and oxidation, but only slightly with temperature. Typical values at wavelengths 2 and 8 μ respectively were 0·09 and 0·04 for polished, 0·30 and 0·24 for roughened, 0·30 and 0·20 for anodized aluminium. Natural oxidation slightly increased the spectral emissivity at all wavelengths below 9 μ and had a marked effect between 10 and 12 μ. An anodic oxide film increased the spectral emissivity beyond 10 μ to greater than 0·70. The significance of these variations to radiation pyrometry is briefly discused.

The emission of negative ions of oxygen from dispenser cathodes. By N. A. Surplice.

(1) *Cathodes of barium oxide in sintered nickel.* Cathodes of sintered nickel and barium oxide have been used as ion sources in simple mass spectrometers and have been found to emit negative ions of atomic oxygen for at least 24 hours during their activation at 1250–1350°k. The evidence suggests that the oxygen is produced by the dissociation of barium oxide and is removed from the cathode by positive ion bombardment. At voltages greater than the ionization potentials of the residual gases the variation of the oxygen ion current I with time t could be expressed as the sum of two exponentially decreasing terms: $I = a \exp(-pt) + b \exp(-qt)$ where p and q were of the order of 2 and 0·2 per hour respectively. Similar results have been obtained with a commercial cathode containing triple carbonates. There appear to be two processes operating in parallel, corresponding to the two terms of the equation. It is postulated that the first process is the diffusion of oxygen through the bulk of the crystals to the nickel part of the cathode's surface, and its removal from there by bombardment with positive ions of oxygen and nitrogen. The second process is the diffusion of oxygen through the pores of the cathode and its removal from the ends of the pores by bombardment with positive ions of barium as well as of the residual gases. The first process has the slower rate of replacement of oxygen and in an hour or two this process is insignificant compared with the second one. If the cathode's surface is temporarily poisoned with oxygen from an external source then it rids itself of the extra oxygen within a few seconds.

(2) *Cathodes of barium aluminate in sintered tungsten.* A cathode of sintered tungsten impregnated with barium aluminate has been studied in a simple mass spectrometer and has been found to emit negative ions of oxygen. About 90% of the oxygen ions were in the atomic form and 10% in the molecular form. The experiments have shown that the ions come from an adsorbed layer of oxygen on the tungsten matrix, from which they are removed by bombardment with positive ions, chiefly of nitrogen. Similar results were obtained with a tungsten matrix without any impregnant.

Some aspects of the self-heating and ignition of solid cellulosic materials. By P. H. Thomas and P. C. Bowes.

The self-heating and self-ignition of fibre insulating board and similar materials are discussed in the light of the well-known theory of thermal explosion. It is pointed out that the simple theory for a single reaction neglecting reactant loss during the induction period is inadequate for the interpretation of all the data published by Mitchell (1951). In the case of wood fibre insulating board it is suggested that the reaction leading to significant increases in temperature at relatively low ambient temperatures is not that responsible for ignition; ignition appears to be mainly the result of other reactions which become appreciable only at higher temperatures. Some experimental results in support of this contention are given, and it is estimated that the activation energy for ignition is 82 cal g^{-1}. The indirect ignitions reported by Mitchell for three materials show one of them (cotton linters) to be different in its behaviour from the other two.

Narrow-beam echo-ranger for fishery and geological investigations. By M. J. Tucker and A. R. Stubbs.

A 36 kc/s underwater acoustic echo-ranger, fitted to R.R.S. *Discovery II* for work on fish detection problems, has also proved to be a valuable tool for marine geological investigations. The axis of the acoustic beam is perpendicular to the fore and aft line of the ship and may be rotated from the horizontal to the downward vertical. Stabilization is provided against the roll of the ship. Beam width and side lobe patterns are adjustable with minimum widths, between 3 db points of 1·3° in plan and 12° in elevation (beam axis horizontal). The recorder provides a range of 800 yards and scanning is achieved by steaming the ship past the features to be investigated.

Measurement of the dielectric constant of filament nylon in a transverse field. By S. F. Ward.

An instrument has been designed for measuring the dielectric constant of a material in the form of a single cylindrical filament, and experiments are described in which it was used for measurements on nylon. The experimental observations were in agreement with existing theory, and the value of 3·9 which was found for the dielectric constant does not differ significantly from the values recorded by other workers for both filament and bulk nylon.

Rubber models of yarns and cords; the 'doubling' of single rods. By N. Wilson and L. R. G. Treloar.

The paper is concerned with the calculation and measurement of the stresses involved in the twisting together of two cylindrical rubber rods, which may be taken as a model of a two-ply cord. Two cases were examined: in the first the rods are initially without twist, while in the second they contain initial twist. The forces measured are the couple about the 'cord' axis and the tension along this axis, as functions of 'cord' twist and 'cord' axial extensions. The forces are calculated on the basis of Rivlin's equations for a thick-walled rubber cylinder subjected to combined axial extension and torsion, corrections being introduced for the effects of lateral pressure between 'plies' on the tensile force, the non-circularity of section resulting from this lateral pressure on the couple due to torsion and bending, and for the effect of torsion on the bending couple.

For the case of zero initial twist in the rods the agreement between calculated and observed forces is good. When initial twist is present, however, there are significant differences, which are not fully understood.

Journal of Scientific Instruments

Uni-axial pantograph. By J. C. Barnes.

A description is given of a simple and effective drafting instrument for changing the scale of a graphical trace along one axis only, leaving the other axis unaltered.

The high-precision isotopic analysis of uranium hexafluoride. By J. Bishop, D. F. Davidson, P. B. F. Evans, A. N. Hamer, J. A. McKnight and E. J. Robbins.

Several factors limit the precision and accuracy which can be achieved in the isotopic analysis of uranium hexafluoride by a mass spectrometer. These include inadequate resolution, memory errors, statistical fluctuations in ion currents, amplifier noise, current noise, inefficient collection of ions, voltage coefficients in resistors and chemical contamination of samples. A description is given of a 90° sector field mass spectrometer of 30 cm radius which has been built and used to investigate the accuracy achievable in practice. The precision (1 σ) of this instrument when measuring the fractional difference in isotope ratio between two samples is 6×10^{-5} at the 50% level of enrichment and $1{\cdot}4 \times 10^{-4}$ with natural uranium, for comparisons lasting 12 minutes. By suitable design of ion source and inlet system, the memory error in the measurement of the concentration difference between two samples has been reduced to ±0·3% of the difference.

Simple millimicrosecond pulse generator. By H. S. Caplan and D. T. Stewart.

The paper describes a hydrogen discharge pulse generator, and gives an application of it to nuclear scintillation counter techniques.

A versatile metal to dielectric seal. By P. C. Conder, H. Foster and H. A. H. Boot.

A bakeable vacuum window seal suitable for use as an optical window or as a radio-frequency window for high power microwave applications is described. Fluid pressure, applied externally, compresses the window frame on to the edge of a dielectric disk. This pressure prevents the frame from expanding away during heating cycles irrespective of the differential thermal expansion between metal and dielectric. Silica and ceramic discs have been successfully sealed to stainless steel or copper frames and baked at 450°c.

Calorimeter for the continuous study of the heat production of microbial systems. By W. W. Forrest.

The calorimeter described is suitable for the continuous study of the heat production of microbial systems. The instrument is self-balancing, heat production in a reaction vessel being simulated by electrical heating of an identical balance vessel. A continuous record of the electrical heat

supplied to the system is presented on a strip-chart. Provision is made for stirring, sampling and maintenance of a controlled atmosphere. The vessels may be sterilized and are inert towards the systems to be studied.

X-ray diffraction data from single crystals at 20°k. By J. D. Forrester.

A liquefier cryostat is used to produce the liquid hydrogen and the crystal is cooled in situ to liquid hydrogen temperature. This method introduces problems involving crystal cooling, crystal mounting, the rotation of the crystal and the provision of x-ray transparent windows in the cryostat walls. These are discussed, together with some preliminary results obtained with the apparatus.

Very high speed dual-purpose image-converter camera. By F. H. Grover.

A laboratory instrument which uses a commercially available image converter tube as a fast shutter for very short exposure photographs of high velocity self-luminous phenomena is described. Exposure times of ten millimicroseconds are obtained with pulses derived from a line pulse circuit having a coaxially constructed thyratron switch. The equipment may also be used for streak photography with a choice of sweep times in the range 1–25 μs.

The stabilization of thermometers of borosilicate glass for use at high temperatures. By J. A. Hall and Vera M. Leaver.

An investigation has been made into the best heat-treatment to be given to thermometers of borosilicate glass before graduation in order to secure good stability in use at temperatures between 400° and 500°c. Zero rises of less than 0·1 deg c per 100 hours at 460°c have been achieved by a stabilization treatment consisting of cooling from 570° to 410°c in not less than 4000 hours. No shorter treatment gave as good a result if the thermometers were used above 410°c. A comparison is made of the performances of three glasses, of German, American and English origin.

A pulse-sampling voltmeter and its application to transistor testing. By L. J. Herbst and J. R. W. Smith.

A pulse-sampling voltmeter designed for measuring low frequency transistor current gain under large signal conditions is described. The method consists of sampling a waveform at approximately 100 c/s with a 20 μs pulse which gates the voltage under test at any required point of the cycle. The segment selected by the pulse is amplified and rectified, its amplitude being determined by a comparison technique in which a variable d.c. voltage is fed to the test set in place of the waveform. The equipment presents an input resistance of at least 200 kΩ on all ranges and measures voltages from 100 mv to 75 v to an accuracy of 1%; the upper limit could be extended.

Correction term for dielectric measurements with cavity resonators. By E. S. Hotston.

The effect of varying the diameter of a polystyrene disk on the value of its dielectric constant when measured in a resonator of fixed diameter is investigated. Agreement is obtained with results predicted by perturbation theory.

A successful version of the Beevers–Macewan Fourier synthesizer using dekatron counters. By J. W. Jeffery.

A modified version of the Beevers–Macewan machine using dekatron counters is described. The machine calculates a Fourier synthesis on exactly the same principle as the Beevers and Lipson strips. A switch selects Cos or Sin; one set of push buttons selects the wave number (0–99) and a second set selects the amplitude (1–100). On pushing the + or — button the machine adds in the numbers on the corresponding strip to 16 counters simultaneously. When all the terms have been put in the result for 0–15/60 of the period, in steps of 1/60, is registered on the counters, negative numbers being given as complements.

The main difficulty in previous designs, which had not been surmounted, was to obtain reliable counters which would work backwards as well as forwards and could be quickly zeroed. This has now been accomplished by utilizing dekatron counters and running the Post Office selector switch at 20 steps per second, the maximum for reliable single stepping operation. A term of amplitude 100 thus requires 5 seconds to put in, but a term of amplitude 10 takes under 1 second because the function-generating uniselector finishes the rotation from position 11 onwards at its normal speed of 200 positions per second.

SPECIAL ARTICLE

Some developments and applications of the optical lever. By R. V. Jones.

The history of the optical lever is briefly reviewed from its invention by Poggendorf in 1826 to the recognition by Ising in 1926 of Brownian fluctuations of a galvanometer in the records obtained by Moll and Burger in 1925 with their thermoelectric relay.

The design of optical levers and amplifiers by the author and his collaborators is outlined; these give sensitivities of the order 10^{-16} radian for a mirror 2·0 mm × 2·0 mm, and an observation bandwidth of 10 c/s. The effects of convection currents and photon fluctuations are indicated. The applications of optical levers to a range of measurements, including Brownian fluctuations, radiation pressure, linear expansion and infra-red detection are described. Optical and photoelectric systems similar to those developed for the optical lever can be used for alignment measurement; applications include refractometry for refractive index changes of order 10^{-8} and a test of the constancy of the velocity of light in a transverse magnetic field.

New quenching circuit of high quenching power and high sensitivity. By B. Kalab.

A circuit is described which produces rectangular quenching pulses of an amplitude up to 2000 v, variable from zero to the maximum value. The change in voltage across the counter is independent of the counting rate. An amplifier of high gain can be used so that the sensitivity is 0·3 mv. Self-oscillation, due to the voltage rise at the end of the quenching period, cannot appear.

A vacuum sluice-valve of large aperture. By P. H. Lisberger.

It is shown that sluice-valves are more suitable than baffle-valves as means of isolating the pumping system in vacuum equipment incorporating a cold-trap. The design and operation of a sluice-valve of 6 in. aperture are then described.

Photoelectric optical pyrometer. By J. Middlehurst and T. P. Jones.

An optical pyrometer is described in which the brightness match is performed photoelectrically. A sensitivity of ±0·02°c at 1063°c is achieved with a reproducibility of ±0·1°c.

A differential absorption spectrometer for the infra-red. By M. D. Sturge.

A method is described of measuring the small change in absorption coefficient due to the introduction of an impurity into a semiconductor. A change of less than 10^{-3} cm^{-1} can be observed in the presence of substantial background absorption. The method is illustrated by a measurement on oxygen-doped germanium.

A recording rotameter using a radioactive float. By D. W. Tims.

An instrument of the type comprising a float in a vertical tapered tube is often suitable for measuring low rates of fluid flow but difficulties arise in obtaining remote indication, recording or control owing to the small physical size of the float and the consequent failure of conventional methods of detecting its position. This paper describes a method in which a radioactivated float and low-voltage, high-current Geiger tubes have been used to overcome these difficulties.

Indium resistance thermometers. By B. Yates and C. H. Panter.

A description is given of the construction of an indium resistance thermometer which is particularly suitable for use in cryostats where working space is limited. The ice point resistance of the thermometer changed by less than 5 parts in 30000 after repeated cooling to 14°k. Mathematical representations of the variation of resistance with temperature are given for the greater part of the temperature range 14 to 323°k.

Proceedings of The Physical Society

Antiferromagnetism of mixed crystals of zinc and manganese fluoride. By J. M. Baker, J. A. Lourens and R. W. H. Stevenson.

An attempt has been made to measure the Néel temperature of mixed crystals of various composition by finding the temperature T_c at which the nuclear magnetic resonance of the fluorine nuclei disappears on cooling from room temperature. The dependence of T_c upon concentration of manganese is compared with theoretical predictions. Measurements of the variation of line width with temperature above T_c is also discussed.

The energy-loss of singly charged heavy relativistic particles in an absorbing material. By C. F. Barnaby.

An experiment is described in which a large area plastic scintillation counter is used to measure the energy-loss of relativistic μ mesons. The results, which are not dependent on the particular method used to fit them to the Landau distribution, show that the increase in the most probable energy loss is less than 1% for mesons of energies between 300 and at least 10000 mev. This conclusion is consistent with the Sternheimer density correction to the ionization loss theory of Bethe–Bloch.

An x-ray absorption process in ionic crystals. By P. E. Best and J. L. Robins.

Two peaks at 9·8 ev and 13·9 ev, in the observed characteristic electron energy loss spectrum of potassium chloride, have been identified as being due to the excitation of surface and volume plasma oscillations respectively. The first two maxima in the chloride ion of the K x-ray absorption spectrum of potassium chloride are of energy 9·8 ev and 13·6 ev greater than the valence → K emission line, and it is proposed that these two peaks are caused by the transition K → valence plus excitation of some mode of plasma oscillation. It is suggested that corresponding peaks in the x-ray absorption spectra of other ionic crystals have the same origin.

The nuclear Zeeman effect and quadrupole splitting in ^{119}Sn. By A. J. F. Boyle, D. St. P. Bunbury and C. Edwards.

The recoilless absorption of 24 kev γ-rays from ^{119m}Sn has been studied with the aid of a velocity spectrometer. Observations with the absorbing nuclei in different environments have enabled a value of 0·63 ± 0·03 n.m. to be given for the magnetic moment of the first excited state in ^{119}Sn, and an upper limit of $3 \cdot 10^{-4}$ ev to be put on the interaction energy between the quadrupole moment of this state and the gradient of the electric field in metallic tin.

The Faraday effect in non-degenerate semiconductors. By B. Donovan and J. Webster.

The theory of the Faraday effect, due to free charge carriers, is developed for non-degenerate semiconductors with spherical energy surfaces. General expressions for the Faraday rotation θ and the ellipticity δ are given, which are valid for all frequencies from the microwave region to the infra-red, and for all magnetic field strengths within the limitations of the Boltzmann equation.

The cases of lattice scattering and impurity scattering are considered separately and the numerical calculations are based on experimental data for n-type germanium. The rotation θ changes sign at the cyclotron resonance frequency in strong fields and at a lower frequency (determined by the relaxation time) in weak fields. The ellipticity δ passes through zero at a frequency corresponding to maximum θ, and reaches a maximum when θ is zero. In the limit of high frequencies and weak fields θ (but not δ) is independent of the relaxation mechanism. Both θ and δ vary linearly with field strength in weak fields but subsequently pass through a maximum. The temperature dependence of θ and δ is examined in the range 100°–300°k for lattice scattering and 15°–100°k for impurity scattering. As the temperature is lowered, in general θ and δ both increase in the case of lattice scattering, and both decrease in the case of impurity scattering.

Hyperfine structure of the level $5^2P_{\frac{1}{2}}$ of potassium 39. By W. N. Fox and G. W. Series.

The hyperfine structure of the level $5^2P_{\frac{1}{2}}$ of potassium 39 has been measured

by the techniques of optical-radiofrequency double resonance. The magnetic interaction constant $a_{1/2}$ was found to be $0{\cdot}99 \pm 0{\cdot}15$ Mc/s, which leads to the value $4{\cdot}57 \pm 0{\cdot}07$ for the ratio $a_{1/2}/a_{3/2}$. This is significantly lower than the value 5·08 which the Goudsmit–Fermi–Segrè theory would predict. The measured value of the Lande g-factor is $0{\cdot}665 \pm 0{\cdot}003$.

The collective treatment of a Fermi gas: II. By T. Gaskell.
The ground state energy of the free electron gas is calculated using the Rayleigh–Schrödinger variational method with the wave function

$$\Psi = D \prod_{i<j}^{N} f(x_{ij})$$

where D is a determinant of plane waves and $f(x_{ij})$ a correlation function. Consideration of the wave function in terms of the collective coordinates P_k, the fourier components of the density, suggests an accurate approximation for the energy integral which is then evaluated over the coordinates of the particles so that the use of subsidiary conditions is avoided. Effects omitted in the random phase approximation are included and the final results extend continuously over plasma and particle modes and should be valid in the range of densities encountered in real metals. The results agree closely with those of Pines and Nozieres, and of Hubbard obtained by more elaborate methods.

The hole theory of liquids. By J. Grindlay.
It is shown that the partition function occurring in the hole theory of liquids may be expressed in closed form by means of the quasi-chemical approximation alone. The thermodynamic properties of this form are described. It is concluded that this theory fails to provide a satisfactory description of the critical point of the liquid state.

Emission of sub-millimetre electromagnetic radiation from hot plasma in ZETA. By G. N. Harding, M. F. Kimmitt, J. H. Ludlow, P. Portcous, A. C. Prior, V. Roberts.
The first results are reported of experiments using a technique new to plasma research, namely spectroscopy in the far infra-red region (wavelength 0·1–1·6 mm). The shapes of the spectra obtained from ZETA are consistent with the observed radiation being entirely due to free–free transitions (bremsstrahlung) and become characteristic of black-body emission at the longer wavelengths. The measured absolute values of the surface brightness of the discharge are in agreement (subject to reasonable assumptions) with the predictions of quantum theory.

(d–d) Reaction product velocities in SCEPTRE III according to a two-group model. By R. Herdan and T. P. Hughes.
The relation is given between the drift velocity Δ of a hot group of deuterons mixing with a cooler stationary group, and the mean centre-of-mass velocity $\langle W \rangle$ of reacting deuteron pairs. Subject to certain restrictions on temperatures and densities, $\langle W \rangle / \Delta$ can be as high as 3 or more. It is suggested that departures from the Maxwellian distribution may make the ratio large enough to explain results obtained with SCEPTRE III, without invoking any acceleration other than that due to the applied electric field.

Optical model analysis of the elastic scattering of 5·5 MeV ^{3}He by carbon, magnesium, aluminium and copper. By P. E. Hodgson.
Recent measurements of ^{3}He scattering are analysed using the optical model of the interaction, and the values of the parameters of the potentials giving the best fit to the data are obtained.

On the identification of the $K\alpha$–Satellites I: LS region. By Z. Horák.
The lines $\alpha^{13}, \alpha^{1}, \alpha_2, \alpha_3{}^{1}, \alpha_4$ in the spectra of neon and a few of its neighbours ($10 \leqslant Z \leqslant 14$) are identified as $K^{-1}L^{-1} \rightarrow L^{-2}$ transitions. For this purpose the case $\zeta = 10$ was analysed using earlier self-consistent-field results together with optical term-values and intensity considerations. The necessary ζ-dependencies were developed by means of Layzer's theory.

Two channel five nucleon reactions with central forces. By W. Laskar, C. Tate, B. Pardoe, and P. G. Burke.
The two channel five nucleon reaction has been formulated using the resonating group method and including the two groupings D–T, α–He. The central potential used is of Gaussian shape with exchange dependence (Serber and Symmetrical exchange have been mainly investigated). The wave functions for the nuclear ground states are Gaussian (double Gaussian for Deuteron and single Gaussian for T and ^{4}He, the parameter being determined by variational methods to fit the binding energies). Coupled integro-differential equations have been derived for each value of the total spin and angular momentum of the corresponding system. Numerical results have been obtained and are given here.

Passage of charged particles through an electron plasma placed in an external magnetic field. By S. K. Majumdar.
The motion of a charged particle through a low-density electron plasma placed in a magnetic field has been investigated, using Maxwell's equations for electromagnetic field and equation of momentum transfer in a plasma. Only the case where the motion of the charged particle is along the direction of the magnetic field, has been considered. Expressions are derived for ordinary and extraordinary indices of refraction for any general propagation direction of transverse waves with respect to magnetic field. The loss of energy by the particle in the form of Cerenkov radiation has also been calculated.

Luminescence excitation spectrum of diamond near the fundamental absorption edge. By J. C. Mole.
Luminescence excitation spectra have been obtained, at room temperature, for 13 natural diamonds comprising six of type I, three of type IIa, three of 'intermediate' type and a single, semiconducting diamond. Excitation peaks, corresponding in detail to the well-known absorption bands at 5·250 eV and 5·393 eV, were detected in all except the semiconducting crystal, and indications of further structure in this energy region were seen. In the region of fundamental optical absorption, broad excitation bands with maxima at 5·51 eV, 5·56 eV and 5·73 eV occur in all but the semiconducting crystal. The semiconducting diamond showed unique features consistent with the presence of an acceptor level within 0·35 eV of the valence band. The luminescence emission spectrum appears to be independent of the quantum energy of the exciting radiation.
Luminescence decay times of 10 millisecnds have generally been found, but for the semiconducting diamond the decay time was six seconds.

The angular distributions of alpha particle groups from the reaction ^{24}Mg (^{3}He, α) ^{23}Mg. By G. Parry, H. D. Scott and S. Swierszczewski.
Angular distributions of two alpha particle groups from the reaction ^{24}Mg(^{3}He, α)^{23}Mg at 5·5 MeV incident beam energy have been measured by magnetic analysis. For both groups a peak is observed in the forward direction, but for one of the groups an additional peak is observed at large angles of observation. An attempt has been made to explain the results in terms of a direct interaction mechanism.

Magnetic anisotropy and rotational hysteresis in single crystals of magnetite below the transition temperature. By R. F. Penoyer and R. Cooper.
Torque curves have been measured at 82°K on gallium- and aluminium-substituted single crystals of magnetite. The paper consists of two parts, one dealing with the values of the constants required to describe the intrinsic anisotropy of Fe_3O_4 below the crystallographic transition and the other is concerned with the irreversible nature of the torque curves observed on some of the gallium substituted crystal. A model based on the ordering of Fe^{2+} and Fe^{3+} ions is proposed to explain this rotational hysteresis which occurs in higher fields than would be necessary for magnetic saturation.

Plasma diffusion in systems with particle losses. By N. J. Phillips.
In certain experimental fusion devices, plasma is confined by a magnetic field and steadily lost out of the ends of a magnetic bottle. When the scattering of particles is high, field diffusion and particle loss must be considered from a macroscopic point of view. The formation of a steady state sheath into which particles diffuse only to be lost along the lines of force was suggested by Wright and Phillips in 1960. The elementary theory is considerably developed here into a state in which the original approximations are evident. It is shown that a steady state plasma sheath may be formed whose thickness depends on the plasma resistivity, sound speed and losses. The sheath moves into the plasma with speed which depends on the same parameters. The plasma resistivity may not be just due to binary collisions and may be due to microscopic instabilities. It is suggested that particle losses may help to generate and maintain instabilities. It is concluded that when binary collisions are no longer important in scattering the electrons, then collective effects take over.

The differential electron density spectrum of air showers at high densities. By R. J. Reid, K. Gopalsingh, D. E. Page, M. C. B. A. McCusker, J. Malos, D. D. Millar and G. Winterton.
The density spectrum of cosmic ray air showers has been measured using Wilson cloud chambers in two different density regions. From 50 to 500 particles per square metre the differential spectrum can be approximated by a power law of exponent $-2{\cdot}5$, in good agreement with many previous results. Above 1100 particles per square metre the measured exponent is $-3{\cdot}9 \pm 5$. The result is compared with recent experiments using emulsion chambers and an explanation is outlined.

A correction to the Smoluchowski equation in the molecular theory of liquids. By A. Suddaby and J. R. N. Miles.
The Smoluchowski equation has been used to obtain the distribution function in coordinate space of pairs of molecules in a non-uniform liquid and hence to calculate the viscosity and flow anisotropy. This equation is the first approximation in an expansion of the Kramers–Chandrasekhar equation in inverse powers of the friction constant. In this paper, the second approximation, which leads to a fourth-order differential equation, is considered. The equation is solved numerically and the contributions to the radial distortion of the pair distribution and to the flow anisotropy are calculated for chloroform. It is found that the friction constant must be at least 8×10^{13} sec^{-1} for the Smoluchowski equation to be a reasonable approximation.

Energy levels in the forbidden gap of insulating diamonds. By R. R. Urlau, the late H. J. Logie and F. R. N. Nabarro.
Two type I diamonds and one type IIa have been examined for the following properties: counting of beta particles in the dark, counting under space charge, effect of monochromatic illumination on counting under an applied field and under space charge, change of total charge while counting and while conducting, and photoconductivity. On the basis of these observations and of the known optical absorption of diamonds of these types a preliminary level scheme is proposed as follows. (i) A level 0·94 ev above the valence band. This level provides traps for holes, is normally filled, but gives rise to photoconductivity on exposure to electron bombardment or irradiation with energetic ultra-violet light. (ii) A level 1·6 ev above the valence band. This level also provides traps for holes and is tentatively identified with the Kaiser–Bond nitrogen level. (iii) A level 3·3 ev above the valence band. This level is partly filled and provides traps for electrons. It can give rise to either n- or p-type photoconductivity.

On the indication of vibration nodes by fine powders. By A. F. B. Wood.
A simple analysis of the dynamics of small particles on a vibrating surface supports the conclusions of earlier workers as to the direction of motion of the particles and the nodes at which they accumulate. These conclusions are further verified by observing the nodal patterns indicated on a vibrating quartz disk whose mode of vibration is accurately known from observations made by other methods.

LETTERS TO THE EDITOR

Cross sections in the proton spectra from the ^{51}V (d, p) ^{52}V reaction. By A. W. Dalton, G. Parry and H. D. Scott.

Kinetic energy effects in the thermal neutron fission of ^{233}U. By T. J. Gooding.

CORRECTION

On page 350 of the December 1963 *Bulletin* in the summary of the paper by R. Orbach, "On the theory of spin-lattice relaxation in paramagnetic salts" it was stated that "the relaxation rate varies as H^2T and [a exp $(-\Delta/kT) + bT^5$] for direct and Raman processes respectively". This was a misprint. The correct expression is "relaxation rate varies as H^2T and [a exp$(-\Delta/kT) + bT^5$]."

B.I.C.C.
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   Experience of calorimetry and in handling radioactive materials desirable.
2. **Senior Scientific Officer** (Ref. 1831/A/110) to investigate the physical effects of gamma radiation and to make associated measurements and calculations. Experience of gamma radiation scattering and dosimetry desirable.
3. **Senior Scientific Officer or Scientific Officer** (Ref. 1838/110) to take charge of a small section working on the application of radioactive isotopes to mechanical wear problems. Work includes practical and fundamental investigations.
   Significant experience in this work or in metal physics would be an advantage.

Applicants for all posts should have a first or good second class honours degree.

Starting Salary in the following ranges according to age and experience:

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Housing and superannuation schemes.

Send Post Card for details to the **Personnel Manager (quoting appropriate Ref. No.), A.E.R.E. Harwell, Didcot, Berks.**

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Principal: C. Chew, M.Sc.Tech. F.R.I.C.

Department of Electrical Engineering and Physics

Applications are invited for **LECTURESHIPS IN PHYSICS** (men or women), duties to commence as soon as possible. Applicants should possess a good degree or equivalent professional qualifications in Physics and experience either in teaching (full-time or part-time) in research or industry.

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George Taylor,
Chief Education Officer.
Education Department,
Leeds, 1.

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Applications are invited for appointment to the above-named position in the Department of Physics. The salary range for the position is £A2,450–£100–£2,950 per annum with superannuation similar to F.S.S.U. The construction of a new building to house the Department of Physics commenced recently and it is anticipated that the building will be ready for occupation by the middle of 1962. The appointee will be required to commence duties as early as possible. It is important that intending applicants obtain details of the procedure to be followed in applying for the post and a copy of the Conditions of Appointment, before submitting their applications. This information is available from the Secretary, Association of Universities of the British Commonwealth, 36 Gordon Square, London, W.C.1. Applications close in Australia and London on March 31, 1961.

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Please write giving brief details of age and experience to the:

Staff Manager, Hexagon House, Blackley, Manchester, 9,

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POST-DOCTORAL FELLOWSHIPS IN PHYSICS

Applications are invited for National Research Council and other Post-Doctoral Fellowships tenable in the Department of Physics, McMaster University. Successful applicants may choose to work full-time on their research or to supplement their research with a modest amount of lecturing. Inquiries and applications should be addressed to Professor H. E. Duckworth, Chairman, Department of Physics, McMaster University, Hamilton, Ontario, Canada.

NATIONAL INSTITUTE FOR RESEARCH IN DAIRYING
UNIVERSITY OF READING

ASSISTANT EXPERIMENTAL OFFICER required in PHYSICS DEPARTMENT to assist in studies of physical properties of dairy products—butter and cheese, etc. He will also be required to construct and modify experimental testing equipment in the department workshop, and skill in using a lathe would be advantageous. Candidates should possess H.N.C. or pass degree, of, if under 22, G.C.E. "A" level or equivalent. Starting salary within range £450 10s. 0d. (at 18) to £776 (at 26) in scale to £983; pension scheme. Apply, naming two referees to Secretary, N.I.R.D., Shinfield, Reading. Quote ref. 61/4.

AUSTRALIAN NATIONAL UNIVERSITY
SCHOOL OF GENERAL STUDIES
SENIOR LECTURER OR LECTURER IN PHYSICS

Applications are invited for appointment to new posts in physics at the level of Senior Lecturer or Lecturer. More than one appointment may be made. The salary range for a Senior Lecturer is £A2,400–£100–£2,900; and for a Lecturer, £A1,640–£90–£A2,360. Commencing salary will be in accordance with qualifications and experience. Further information and the summary forms which must accompany an application may be obtained from the Secretary, Association of Universities of the British Commonwealth, 36 Gordon Square, London, W.C.1. Applications close, in Australia and London, on March 4, 1961.

RHODES UNIVERSITY
GRAHAMSTOWN, SOUTH AFRICA
PROFESSOR OF PURE MATHEMATICS

Applications are invited for the above-mentioned post from July, 1961. The salary scale is £2,200 × £100–£2,700 p.a. A vacation savings bonus, as in the Public Service, is also payable. Previous experience and academic qualifications may be taken into account in fixing the commencing salary. Full particulars and application forms may be obtained from the Secretary, Association of Universities of the British Commonwealth, 36 Gordon Square, London, W.C.1. Applications close, in South Africa and London, on March 20, 1961.

ESSEX COLLEGE

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The Department of Physics offers GRADUATE ASSISTANTSHIPS to candidates wishing to proceed to an M.Sc. in Physics. Stipend up to $2,000 for eight months, depending on qualifications and duties in the department. There is a possibility of additional income during the Summer months. At present research is proceeding in beta-ray spectroscopy, optical pumping, molecular collision problems, and electromagnetic interactions in shock waves. Enquiries should be addressed to The Chairman, Department of Physics, Assumption University of Windsor.

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AUSTRALIA

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As one of the three Divisions comprising the National Standards Laboratory, it is concerned with the maintenance of standards for length, mass and related matters. The appointee must be capable of initiating research into, and development of, new and improved measuring techniques and equipment in engineering metrology, particularly in large scale metrology, dynamic metrology, and gears and gear cutting equipment.

Salary: dependent on qualifications and experience within the ranges:—£A1,510–£2,265 p.a. or £A2,395–£2,720 p.a.

Salary for women will be £A180 p.a. less than corresponding rates for men. Promotion within C.S.I.R.O. is by merit and may ultimately go beyond the upper limit of the range within which the original appointment is made.

Fares paid. Further details of conditions, etc., supplied on application to:—Mr. E. J. Drake, Chief Scientific Liaison Officer, Australian Scientific Liaison Office, Africa House, Kingsway, London, W.C.2. to whom applications (quoting Appointment No: 750/188) should be addressed by **March 4, 1961.**

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COURSES

UNIVERSITY OF LEEDS
Houldsworth School of Applied Science
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April 10–May 10, 1961

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BATTERSEA COLLEGE OF TECHNOLOGY
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A vacation course, arranged by the Crystallography Section, on APPLICATIONS OF ELECTRON DIFFRACTION will be held on April 13 and 14, 1961. The Course is suitable for users and potential users of electron diffraction techniques in science and industry. Fee £3 3s. 0d. Further details and enrolment forms may be obtained from the Secretary (Crystallography Courses).

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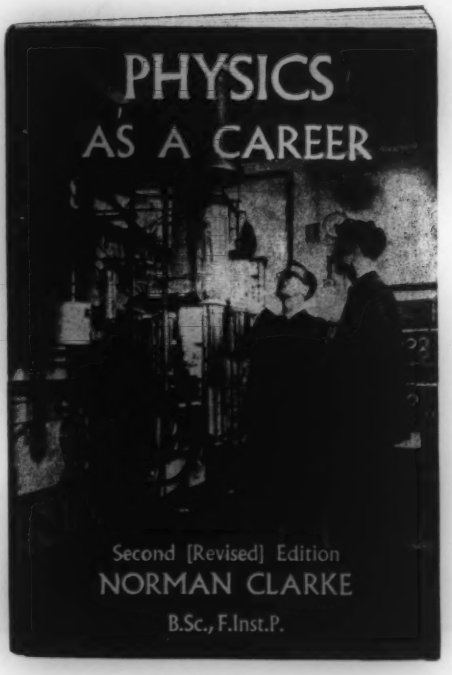

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